Copy 6
RM L55A21

[redacted]

# RESEARCH MEMORANDUM

## STATIC LONGITUDINAL AND LATERAL STABILITY DATA FROM AN EXPLORATORY INVESTIGATION AT MACH NUMBER 4.06 OF AN AIRPLANE CONFIGURATION HAVING A WING OF TRAPEZOIDAL PLAN FORM

By Robert W. Dunning and Edward F. Ulmann

Langley Aeronautical Laboratory
Langley Field, Va.



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

February 15, 1955

[redacted]

 [redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

# STATIC LONGITUDINAL AND LATERAL STABILITY DATA FROM AN EXPLORATORY INVESTIGATION AT MACH NUMBER 4.06 OF AN AIRPLANE CONFIGURATION HAVING A WING OF TRAPEZOIDAL PLAN FORM

By Robert W. Dunning and Edward F. Ulmann

## SUMMARY

An investigation to determine the static longitudinal and lateral stability characteristics of an airplane configuration having a trapezoidal wing with modified hexagonal airfoil section and a cruciform tail with $5^{\circ}$ semiangle wedge section has been carried out in the Langley 9- by 9-inch Mach number 4 blowdown jet. Tests on the complete airplane and various combinations of its components were made at a Mach number of 4.06 and a Reynolds number of $2.7 \times 10^{6}$, based on wing mean aerodynamic chord. Data were obtained for angles of attack from $0^{\circ}$ to a maximum of $8^{\circ}$ to $20^{\circ}$, at angles of sideslip from $0^{\circ}$ up to a maximum of $5^{\circ}$ to $8^{\circ}$, the maximum values depending on the configuration tested. The data are presented with respect to body axes except for lift and drag which are referred to the stability axes.

## INTRODUCTION

The aircraft configurations previously investigated experimentally at high supersonic and hypersonic speeds have been restricted to missiles which were not required to land, and which therefore had relatively small wings or wings of very low aspect ratio. The purpose of the present investigation was to determine the characteristics of a configuration conforming more closely to a piloted aircraft having a wing area sufficient for conventional landing. Of the various possible configurations, one was selected for this exploratory study which was expected to have satisfactory low-speed characteristics and satisfactory transonic characteristics. This configuration (fig. 1) employs a trapezoidal wing and the arrangement, in general, is similar to that of conventional airplanes.

[redacted]

Two particular features were incorporated which are believed to be desirable for high supersonic and hypersonic operation - relatively large leading-edge radii for both wing and tail and wedge-shaped sections for the tail surfaces. The wing and tail sections were designed with large leading-edge radii because of heat-transfer considerations at high Mach numbers. The wing leading-edge radius, for example, would be approximately 1.5 inches at the wing-fuselage intersection for a full-size airplane having a wing span of about 28 feet. Inasmuch as the effectiveness of lifting surfaces having flat-plate or conventional airfoil sections decreases considerably with Mach number at high supersonic speeds (ref. 1), the effectiveness of tail surfaces of conventional size utilizing these airfoil sections would be marginal or insufficient at the Mach number of the present tests. Several types of tail airfoil sections therefore are being considered and the present results were obtained with a $5^{\circ}$ semiangle wedge section.

In references 2 and 3, longitudinal and lateral stability data were presented for this same configuration at Mach number 6.86. This report presents the static longitudinal and lateral stability characteristics at Mach number 4.06 without analysis in order to expedite publication.

## SYMBOLS

The results of the tests are presented as standard NACA coefficients of forces and moments. The data are referred to the body axes except for lift and drag which are referred to the stability axes (fig. 2), with the reference center of gravity at 52.66 percent body length from the body nose (54 percent mean aerodynamic chord).

$C_N$ normal-force coefficient, $-Z_B/qS$

$C_L$ lift coefficient, $-Z_S/qS$

$C_{D_T}$ total drag coefficient, $-X_{B_T}/qS$

$C_{D_B}$ base drag coefficient, $-X_{B_B}/qS$

$C_{m_{c.g.}}$ pitching-moment coefficient about center of gravity, $M'/qS\bar{c}$

$C_Y$ lateral-force coefficient, $Y/qS$

$C_n$ yawing-moment coefficient about center of gravity, $N/qSb$

| | |
|---|---|
| $C_l$ | rolling-moment coefficient, $L/qSb$ |
| $Z_B$ | force along $Z_B$-axis |
| $Z_S$ | force along $Z_S$-axis |
| $X_{B_T}$ | total force along $X_B$-axis |
| $X_{B_B}$ | force along $X_B$-axis contributed by base |
| M' | moment about Y-axis |
| Y | force along Y-axis |
| N | moment about $Z_B$-axis |
| L | moment about $X_B$-axis |
| q | free-stream dynamic pressure |
| S | total wing area, including body intercept |
| $\bar{c}$ | wing mean aerodynamic chord |
| b | wing span |
| $L/D_T$ | lift-drag ratio, $C_L/C_{D_T}$ |
| R | Reynolds number based on $\bar{c}$ |
| M | Mach number |
| c.p. | longitudinal distance from nose to center of pressure, percent body length |
| $\alpha$ | angle of attack of fuselage center line, deg |
| $\beta$ | angle of sideslip, deg |
| $\frac{\partial C_m}{\partial C_L}$ | rate of change of pitching-moment coefficient with lift coefficient |
| $C_{n_\beta}$ | rate of change of yawing-moment coefficient with angle of sideslip |

$C_{l_\beta}$ rate of change of rolling-moment coefficient with angle of sideslip

$C_{Y_\beta}$ rate of change of lateral-force coefficient with angle of sideslip

## APPARATUS

The tests were conducted in the Langley 9- by 9-inch Mach number 4 blowdown jet, which is described and for which a calibration is given in reference 4. The settling-chamber pressure, which was held constant by a pressure-regulating valve, and the corresponding air temperature were continuously recorded during each run.

Two separate internal strain-gage balances were used to obtain the data. One balance measured normal force, pitching moment, side force, yawing moment, and rolling moment. The second balance measured chord force through the angle-of-attack range but was limited to measurements at zero angle of sideslip because of balance design.

Representative schlieren photographs of the flow around the model were made by the use of an off-axis, single-pass, two-mirror schlieren system. Exposure time was 1/200 second, and the knife edge was oriented parallel to the free-stream flow.

## MODELS

The model configurations used for the present tests consisted of a complete airplane (fig. 1), a body alone, a body-wing combination, and a body-tail combination. Details concerning the airplane model are given in the three-view drawing (fig. 3(a)), in the sketches of the airfoil sections (fig. 3(b)), and in the table of geometric characteristics (table I). The wing and tail sections were designed with large leading-edge radii because of heat-transfer considerations at high Mach numbers. A photograph of the complete airplane configuration installed in the Langley 9- by 9-inch Mach number 4 blowdown jet is presented in figure 4.

## TESTS

The settling-chamber stagnation temperature during any single run varied from approximately 80° to 40° F, and the settling-chamber stagnation pressure was held at approximately 186 lb/sq in. abs. These conditions correspond approximately to a Reynolds number of $2.7 \times 10^6$, based on the wing mean aerodynamic chord. The tests were run at humidities below $5 \times 10^{-6}$ pounds of water vapor per pound of dry air, which is believed to be low enough to eliminate water-condensation effects. The test-section static temperature and pressure did not reach the point where liquefaction of air would take place. Data were obtained for angles of attack from $0^{\circ}$ to a maximum of $8^{\circ}$ to $20^{\circ}$, at angles of sideslip from $0^{\circ}$ to a maximum of $5^{\circ}$ to $8^{\circ}$, the maximum values depending on the configuration tested. Base drag data were obtained from static pressures measured at the base of the model.

## PRECISION OF DATA

The probable uncertainties in the test data due to the accuracy limitations of the balances and the recording equipment and the ability of the system to repeat data points are listed in the table below. The low accuracy of the rolling-moment coefficients relative to the maximum rolling-moment encountered should be noted. This occurred because rolling-moment gages were added to an existing balance which was not originally designed to measure rolling moment.

| | |
|---|---|
| $C_N$ | ±0.001 |
| $C_L$ | ±0.001 |
| $C_{D_T}$ | ±0.0003 |
| $C_{m_{c.g.}}$ | ±0.0004 |
| $C_Y$ | ±0.0003 |
| $C_n$ | ±0.00005 |
| $C_l$ | ±0.0009 |
| $\alpha$, deg | ±0.1 |
| $\beta$, deg | ±0.1 |

## RESULTS

The experimental static aerodynamic characteristics of the models are given for all angles of attack and sideslip in tables II and III, and representative portions of the data are presented in the figures. Equations for transferring these coefficients from the body axes to the stability axes are presented in the appendix. The variations with angle of attack of the longitudinal characteristics of the complete airplane and various combinations of its components are presented in figures 5 to 11. In figures 12 and 13 some static longitudinal stability characteristics are presented.

The variations with sideslip angle of the lateral characteristics of the body-wing and complete-airplane configurations are presented in figure 14, and the variations with sideslip angle of the longitudinal characteristics of the body-wing and complete-airplane configurations are presented in figure 15. The effects of normal-force coefficient on the lateral characteristics for the body-wing and complete configurations are presented in figure 16. Some static lateral stability characteristics are presented in figure 17.

Typical schlieren photographs of the components at a constant angle of attack and of the complete model at various angles of attack are presented in figures 18 and 19. The closely spaced disturbances which can be seen extending downstream at the top and the bottom of the schlieren field of view are caused by the tips of 1/4-inch-diameter rods which support the model against shock loads during the starting and stopping cycles of the tunnel. The rods are withdrawn into or almost into the tunnel floor and ceiling while data are being taken. The plugged holes in the tunnel floor used for these rods may be seen in figure 4. It should be noted that the model pivots in pitch about a point near the base of the body, and that consequently the tail fins do not move up or down into that part of the flow influenced by the disturbances from the support rods.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 3, 1955.

# APPENDIX

The equations for transfer of force and moment coefficients from the body-axis system to the stability-axis system (fig. 2) are as follows:

$$C_{Y_S} = C_{Y_B}$$

$$C_{l_S} = C_{l_B} \cos \alpha + C_{n_B} \sin \alpha$$

$$C_{n_S} = C_{n_B} \cos \alpha - C_{l_B} \sin \alpha$$

$$C_{m_S} = C_{m_B}$$

Since longitudinal forces were measured only for $\beta = 0$, the axis-transfer equations for $C_{L_S}$ and $C_{D_S}$ are not given here.

## REFERENCES

1. McLellan, Charles H.: A Method for Increasing the Effectiveness of Stabilizing Surfaces at High Supersonic Mach Numbers. NACA RM L54F21, 1954.

2. Penland, Jim A., Ridyard, Herbert W., and Fetterman, David E., Jr.: Lift, Drag, and Static Longitudinal Stability Data From an Exploratory Investigation at a Mach Number of 6.86 of an Airplane Configuration Having a Wing of Trapezoidal Plan Form. NACA RM L54L03b, 1955.

3. Ridyard, Herbert W., Fetterman, David E., Jr., and Penland, Jim A.: Static Lateral Stability Data From an Exploratory Investigation at a Mach Number of 6.86 of an Airplane Configuration Having a Wing of Trapezoidal Plan Form. NACA RM L55A21a, 1955.

4. Ulmann, Edward F., and Lord, Douglas R.: An Investigation of Flow Characteristics at Mach Number 4.04 Over 6- and 9-Percent-Thick Symmetrical Circular-Arc Airfoils Having 30-Percent-Chord Trailing-Edge Flaps. NACA RM L51D30, 1951.

TABLE I.- GEOMETRIC CHARACTERISTICS OF MODEL

| | |
|---|---|
| Wing: | |
| Area (including area submerged in fuselage), sq in. | 6.24 |
| Span, in. | 4.33 |
| Mean aerodynamic chord, in. | 1.716 |
| Root chord, in. | 2.53 |
| Tip chord, in. | 0.354 |
| Airfoil section | hexagonal with round leading edge |
| Taper ratio | 0.140 |
| Aspect ratio | 3.00 |
| Sweep of leading edge, deg | 38.83 |
| Sweep of quarter-chord line, deg | 29 |
| Incidence at fuselage center line, deg | 0 |
| Dihedral, deg | 0 |
| Geometric twist, deg | 0 |
| Horizontal tail or vertical tail: | |
| Area (including area submerged in fuselage), sq in. | 2.06 |
| Span, in. | 2.69 |
| Mean aerodynamic chord, in. | 0.853 |
| Root chord, in. | 1.214 |
| Tip chord, in. | 0.317 |
| Airfoil section | $5^{\circ}$ semiangle wedge |
| Taper ratio | 0.261 |
| Aspect ratio | 3.52 |
| Sweep of leading edge, deg | 22.63 |
| Dihedral, deg | 0 |
| Fuselage: | |
| Length, in. | 7.50 |
| Maximum diameter, in. | 0.790 |
| Fineness ratio | 9.50 |
| Base diameter, in. | 0.790 |
| Distance from nose to moment reference | 3.950 |
| Ogive nose length, in. | 2.29 |
| Ogive radius, in. | 6.85 |

TABLE II.- STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS. BODY AXIS DATA. $M = 4.06$. $R = 2.7 \times 10^6$.

(a) Body-wing-tail

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0023 | 0.0001 | 53.7 | -0.0001 | 0.0001 | 0.0009 |
| | 1.0 | -.0023 | .0002 | 54.7 | -.0110 | .0026 | .0008 |
| | 2.0 | -.0017 | 0.0 | 52.7 | -.0223 | .0050 | .0007 |
| | 3.0 | -.0017 | 0.0 | 52.7 | -.0341 | .0077 | .0004 |
| | 4.0 | -.0016 | 0.0 | 52.7 | -.0454 | .0102 | .0003 |
| | 5.0 | -.0048 | .0011 | 57.9 | -.0570 | .0124 | .0004 |
| 2.0 | 0.0 | 0.0484 | -0.0125 | 58.6 | 0.0010 | 0.0 | .0002 |
| | 1.0 | .0484 | -.0127 | 58.7 | -.0102 | .0025 | .0001 |
| | 2.0 | .0483 | -.0129 | 58.8 | -.0215 | .0050 | 0.0 |
| | 3.0 | .0472 | -.0129 | 58.9 | -.0334 | .0076 | 0.0 |
| | 4.0 | .0466 | -.0131 | 59.1 | -.0451 | .0101 | .0006 |
| | 5.0 | .0461 | -.0131 | 59.2 | -.0571 | .0124 | .0006 |
| 4.0 | 0.0 | 0.1002 | -0.0248 | 58.3 | 0.0020 | -0.0002 | 0.0 |
| | 0.0 | .1009 | -.0253 | 58.4 | .0019 | -.0002 | .0011 |
| | 0.0 | .1019 | -.0256 | 58.4 | .0024 | -.0002 | -.0004 |
| | 1.0 | .1025 | -.0255 | 58.4 | -.0098 | .0023 | .0014 |
| | 1.0 | .1020 | -.0256 | 58.4 | -.0095 | .0023 | -.0003 |
| | 2.0 | .1025 | -.0257 | 58.4 | -.0208 | .0048 | .0015 |
| | 2.0 | .1016 | -.0257 | 58.5 | -.0206 | .0047 | -.0002 |
| | 3.0 | .1032 | -.0256 | 58.4 | -.0329 | .0074 | .0011 |
| | 3.0 | .1019 | -.0258 | 58.5 | -.0330 | .0074 | 0.0 |
| | 4.0 | .1037 | -.0256 | 58.3 | -.0458 | .0101 | .0009 |
| | 4.0 | .1019 | -.0259 | 58.5 | -.0455 | .0100 | .0002 |
| | 5.0 | .1038 | -.0258 | 58.4 | -.0579 | .0125 | .0009 |
| | 5.0 | .1024 | -.0262 | 58.5 | -.0575 | .0125 | 0.0 |
| 6.0 | 0.0 | 0.1614 | -0.0408 | 58.5 | 0.0029 | -0.0003 | 0.0001 |
| | 1.0 | .1554 | -.0387 | 58.4 | -.0091 | .0024 | .0001 |
| | 2.0 | .1546 | -.0380 | 58.3 | -.0204 | .0047 | .0004 |
| | 3.0 | .1557 | -.0378 | 58.2 | -.0335 | .0074 | .0004 |
| | 4.0 | .1554 | -.0374 | 58.2 | -.0450 | .0099 | .0006 |

TABLE II.- STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS.

BODY AXIS DATA. $M = 4.06$. $R = 2.7 \times 10^6$ - Continued

(a) Body-wing-tail - Concluded

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 8.0 | 0.0 | 0.2142 | -0.0534 | 58.4 | 0.0033 | -0.0003 | -0.0004 |
| ↓ | 1.0 | .2142 | -.0531 | 58.3 | -.0098 | .0025 | -.0002 |

(b) Body

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0017 | -0.0011 | 37.9 | -0.0002 | 0.0001 | 0.0005 |
| 2.0 | 0.0 | .0067 | .0085 | 23.6 | .0001 | .0002 | .0009 |
| 4.0 | 0.0 | .0178 | .0184 | 29.0 | .0003 | .0003 | .0009 |
| 6.0 | 0.0 | .0327 | .0248 | 35.3 | .0005 | .0002 | .0008 |
| 8.0 | 0.0 | .0502 | .0271 | 40.3 | .0011 | .0002 | .0007 |
| 10.0 | 0.0 | .0709 | .0301 | 43.0 | .0011 | .0002 | .0004 |
| 12.0 | 0.0 | .0908 | .0338 | 44.2 | .0017 | .0003 | .0001 |
| 14.0 | 0.0 | .1119 | .0378 | 44.9 | .0022 | .0004 | -.0004 |
| 15.0 | 0.0 | .1220 | .0390 | 45.4 | .0019 | .0003 | .0009 |
| 16.0 | 0.0 | .1326 | .0398 | 45.8 | .0021 | .0004 | .0008 |
| 18.0 | 0.0 | .1585 | .0401 | 46.9 | .0026 | .0004 | .0003 |
| 20.0 | 0.0 | .1858 | .0402 | 47.7 | .0043 | .0003 | .0002 |

(c) Body-wing

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | 0.0045 | 0.0009 | 48.1 | 0.0007 | 0.0001 | 0.0015 |
| | 1.0 | .0050 | .0009 | 48.6 | -.0034 | -.0016 | .0013 |
| | 2.0 | .0029 | .0007 | 47.2 | -.0083 | -.0034 | .0013 |
| | 3.0 | .0025 | .0005 | 48.1 | -.0129 | -.0051 | .0010 |
| | 4.0 | .0004 | 0.0 | 52.7 | -.0182 | -.0067 | .0006 |
| | 5.0 | -.0011 | -.0003 | 46.4 | -.0236 | -.0080 | .0003 |
| | 6.0 | -.0021 | -.0004 | 48.3 | -.0307 | -.0091 | -.0001 |
| | 7.0 | -.0006 | -.0001 | 48.9 | -.0387 | -.0098 | .0004 |
| ↓ | 8.0 | -.0001 | 0.0 | 52.7 | -.0477 | -.0103 | .0007 |

TABLE II.- STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS. BODY AXIS DATA. M = 4.06.

$R = 2.7 \times 10^6$ - Continued

(c) Body-wing - Continued

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 2.0 | 0.0 | 0.0368 | 0.0041 | 50.1 | 0.0009 | 0.0002 | 0.0001 |
| | 1.0 | .0372 | .0044 | 50.0 | -.0035 | -.0016 | .0001 |
| | 2.0 | .0366 | .0047 | 49.7 | -.0078 | -.0033 | .0 |
| | 3.0 | .0365 | .0048 | 49.7 | -.0130 | -.0050 | -.0001 |
| | 4.0 | .0364 | .0049 | 49.6 | -.0180 | -.0067 | .0001 |
| | 5.0 | .0375 | .0051 | 49.6 | -.0238 | -.0080 | .0001 |
| | 6.0 | .0380 | .0053 | 49.5 | -.0308 | -.0091 | -.0002 |
| | 7.0 | .0385 | .0054 | 49.5 | -.0389 | -.0099 | -.0003 |
| | 8.0 | .0383 | .0052 | 49.6 | -.0473 | -.0103 | .0005 |
| 4.0 | 0.0 | 0.0812 | 0.0092 | 50.1 | 0.0019 | 0.0004 | 0.0010 |
| | 1.0 | .0818 | .0095 | 50.0 | -.0028 | -.0016 | .0007 |
| | 2.0 | .0825 | .0100 | 49.9 | -.0071 | -.0032 | .0007 |
| | 3.0 | .0822 | .0103 | 49.8 | -.0123 | -.0050 | .0004 |
| | 4.0 | .0824 | .0107 | 49.7 | -.0175 | -.0065 | .0003 |
| | 5.0 | .0831 | .0110 | 49.6 | -.0237 | -.0079 | .0003 |
| | 6.0 | .0837 | .0110 | 49.7 | -.0308 | -.0090 | .0002 |
| | 7.0 | .0847 | .0110 | 49.7 | -.0394 | -.0100 | .0 |
| | 8.0 | .0855 | .0108 | 49.8 | -.0472 | -.0105 | .0001 |
| 6.0 | 0.0 | 0.1262 | 0.0137 | 50.2 | 0.0021 | 0.0003 | 0.0008 |
| | 1.0 | .1259 | .0138 | 50.2 | -.0027 | -.0017 | .0007 |
| | 2.0 | .1259 | .0141 | 50.1 | -.0073 | -.0035 | .0006 |
| | 3.0 | .1266 | .0149 | 50.0 | -.0132 | -.0054 | .0005 |
| | 4.0 | .1266 | .0153 | 49.9 | -.0186 | -.0068 | .0005 |
| | 5.0 | .1273 | .0154 | 49.9 | -.0248 | -.0082 | .0004 |
| | 6.0 | .1289 | .0156 | 49.9 | -.0321 | -.0094 | .0003 |
| | 7.0 | .1296 | .0158 | 49.9 | -.0407 | -.0104 | .0001 |
| 6.1 | 8.0 | .1302 | .0159 | 49.9 | -.0486 | -.0109 | -.0002 |
| 8.0 | 0.0 | 0.1730 | 0.0165 | 50.5 | 0.0026 | 0.0003 | .0007 |
| | 1.0 | .1727 | .0167 | 50.5 | -.0027 | -.0016 | .0008 |
| | 2.0 | .1727 | .0170 | 50.4 | -.0080 | -.0035 | .0005 |
| | 3.0 | .1722 | .0176 | 50.3 | -.0138 | -.0053 | .0003 |
| | 4.0 | .1728 | .0184 | 50.2 | -.0200 | -.0068 | .0 |
| | 5.0 | .1735 | .0191 | 50.2 | -.0266 | -.0082 | -.0001 |
| | 5.9 | .1746 | .0200 | 50.1 | -.0335 | -.0096 | -.0009 |
| 8.1 | 6.9 | .1760 | .0204 | 50.0 | -.0420 | -.0104 | -.0008 |
| 8.1 | 7.9 | .1775 | .0208 | 50.0 | -.0506 | -.0110 | -.0009 |

TABLE II.- STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS. BODY AXIS DATA. M = 4.06.

R = 2.7 × $10^6$ - Continued

(c) Body-wing - Concluded

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 10.0 | 0.0 | 0.2275 | 0.0185 | 50.8 | 0.0038 | 0.0003 | -0.0001 |
| ↓ | 1.0 | .2278 | .0189 | 50.8 | -.0027 | -.0015 | -.0005 |
| ↓ | 2.0 | .2279 | .0195 | 50.7 | -.0086 | -.0032 | -.0006 |
| ↓ | 3.0 | .2279 | .0200 | 50.7 | -.0154 | -.0051 | -.0008 |
| ↓ | 3.9 | .2274 | .0213 | 50.5 | -.0220 | -.0065 | -.0012 |
| ↓ | 4.9 | .2234 | .0225 | 50.4 | -.0292 | -.0077 | -.0013 |
| 10.1 | 5.9 | .2251 | .0234 | 50.3 | -.0366 | -.0089 | -.0014 |
| 10.1 | 6.9 | .2267 | .0243 | 50.2 | -.0449 | -.0100 | -.0015 |
| 10.1 | 7.9 | .2271 | .0250 | 50.2 | -.0538 | -.0110 | -.0017 |
| 12.0 | 0.0 | 0.2858 | 0.0196 | 51.1 | 0.0040 | 0.0004 | -0.0004 |
| ↓ | 1.0 | .2855 | .0194 | 51.1 | -.0030 | -.0013 | -.0009 |
| ↓ | 2.0 | .2850 | .0199 | 51.1 | -.0097 | -.0028 | -.0011 |
| ↓ | 2.9 | .2851 | .0211 | 51.0 | -.0176 | -.0045 | -.0013 |
| ↓ | 3.9 | .2834 | .0232 | 50.8 | -.0244 | -.0057 | -.0023 |
| ↓ | 4.9 | .2811 | .0247 | 50.7 | -.0324 | -.0068 | -.0027 |
| 12.1 | 5.9 | .2819 | .0262 | 50.5 | -.0408 | -.0079 | -.0028 |
| 12.1 | 6.9 | .2818 | .0278 | 50.4 | -.0494 | -.0090 | -.0032 |
| 12.1 | 7.8 | .2824 | .0292 | 50.3 | -.0577 | -.0100 | -.0031 |

(d) Body-tail

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0027 | 0.0002 | 54.4 | -0.0006 | 0.0 | 0.0002 |
| ↓ | 1.0 | -.0027 | .0002 | 54.4 | -.0119 | .0025 | .0001 |
| ↓ | 2.0 | -.0033 | .0 | 52.7 | -.0232 | .0050 | .0006 |
| ↓ | 3.0 | -.0038 | .0003 | 54.5 | -.0355 | .0077 | .0007 |
| ↓ | 4.0 | -.0033 | .0004 | 55.4 | -.0469 | .0102 | .0008 |
| ↓ | 5.0 | -.0027 | .0004 | 56.1 | -.0586 | .0128 | .0005 |
| 2.0 | 0.0 | 0.0202 | -0.0113 | 65.5 | 0.0001 | -0.0001 | 0.0004 |
| ↓ | 1.0 | .0202 | -.0113 | 65.5 | -.0114 | .0026 | .0003 |
| ↓ | 2.0 | .0202 | -.0116 | 65.8 | -.0225 | .0051 | .0002 |
| ↓ | 3.0 | .0202 | -.0118 | 66.0 | -.0348 | .0078 | .0 |
| ↓ | 4.0 | .0202 | -.0119 | 66.2 | -.0470 | .0104 | .0001 |
| ↓ | 5.0 | .0206 | -.0122 | 66.2 | -.0586 | .0128 | .0005 |

TABLE II.- STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS. BODY AXIS DATA. $M = 4.06$. $R = 2.7 \times 10^6$ - Concluded

(d) Body-tail - Concluded

| $\alpha$ | $\beta$ | $C_N$ | $C_{m_{c.g.}}$ | c.p. | $C_Y$ | $C_n$ | $C_l$ |
|---|---|---|---|---|---|---|---|
| 4.0 | 0.0 | 0.0417 | -0.0253 | 66.6 | 0.0008 | -0.0001 | -0.0003 |
| | 0.0 | .0433 | -.0246 | 65.7 | .0013 | -.0002 | .0001 |
| | 1.0 | .0422 | -.0254 | 66.4 | -.0114 | .0025 | .0002 |
| | 1.0 | .0431 | -.0246 | 65.7 | -.0109 | .0025 | -.0001 |
| | 2.0 | .0422 | -.0255 | 66.5 | -.0224 | .0050 | .0007 |
| | 2.0 | .0431 | -.0249 | 65.9 | -.0221 | .0050 | -.0002 |
| | 3.0 | .0427 | -.0257 | 66.4 | -.0347 | .0077 | .0006 |
| | 3.0 | .0441 | -.0254 | 65.9 | -.0346 | .0077 | -.0001 |
| | 4.0 | .0433 | -.0260 | 66.4 | -.0476 | .0104 | .0004 |
| | 4.0 | .0445 | -.0259 | 66.0 | -.0474 | .0104 | .0005 |
| | 5.0 | .0445 | -.0264 | 66.2 | -.0600 | .0129 | .0001 |
| | 5.0 | .0445 | -.0264 | 66.2 | -.0599 | .0129 | .0007 |
| 6.0 | 0.0 | 0.0686 | -0.0394 | 65.8 | 0.0015 | -0.0002 | 0.0004 |
| | 1.0 | .0691 | -.0395 | 65.8 | -.0110 | .0026 | .0003 |
| | 2.0 | .0691 | -.0397 | 65.8 | -.0224 | .0050 | -.0001 |
| | 3.0 | .0691 | -.0393 | 65.7 | -.0361 | .0079 | -.0003 |
| | 4.0 | .0690 | -.0396 | 65.8 | -.0480 | .0105 | -.0003 |
| 8.0 | 0.0 | 0.0951 | -0.0552 | 66.0 | 0.0016 | -0.0002 | 0.0009 |
| | 1.0 | .0953 | -.0552 | 65.9 | -.0113 | .0025 | .0007 |
| | 2.0 | .0953 | -.0547 | 65.8 | -.0228 | .0049 | .0006 |

TABLE III.- STATIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE CONFIGURATION AND VARIOUS COMBINATIONS OF ITS COMPONENTS. STABILITY AXIS DATA.

$M = 4.06. \quad R = 2.7 \times 10^6.$

(a) Body-wing-tail

| $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ | $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0023 | 0.0439 | 0.0056 | -0.05 | 6.0 | 0.0 | 0.1555 | 0.0646 | 0.0056 | 2.41 |
| 2.0 | 0.0 | .0468 | .0475 | .0056 | .99 | 8.0 | 0.0 | .2053 | .0780 | .0055 | 2.63 |
| 4.0 | 0.0 | .0975 | .0534 | .0056 | 1.83 | | | | | | |
| 4.0 | 0.0 | .0977 | .0528 | .0056 | 1.85 | | | | | | |

(b) Body

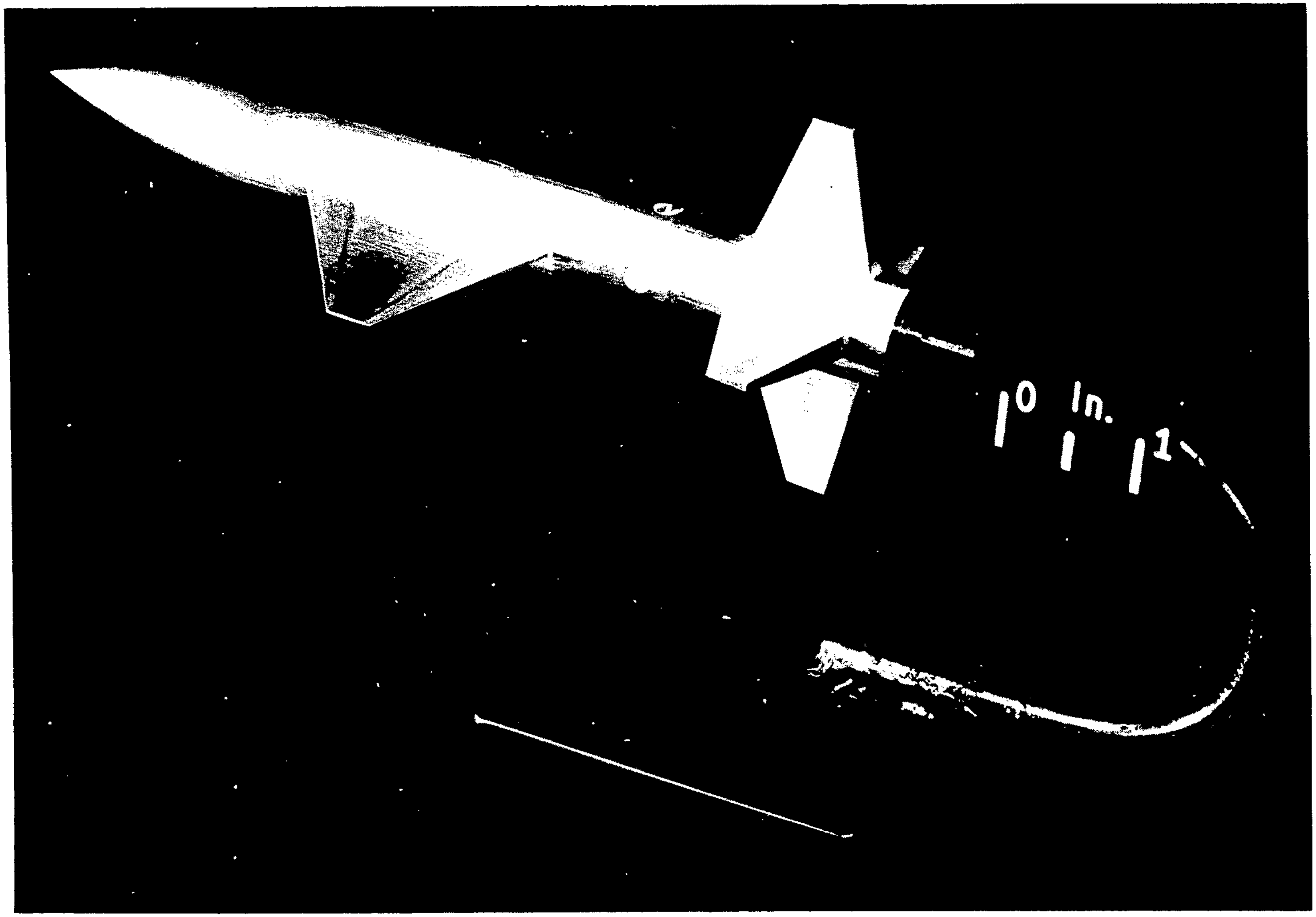
| $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ | $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0017 | 0.0156 | 0.0053 | -0.11 | 12.0 | 0.0 | 0.0847 | 0.0382 | 0.0058 | 2.22 |
| 2.0 | 0.0 | .0061 | .0165 | .0053 | .37 | 14.0 | 0.0 | .1038 | .0463 | .0058 | 2.24 |
| 4.0 | 0.0 | .0166 | .0181 | .0053 | .92 | 15.0 | 0.0 | .1127 | .0509 | .0058 | 2.21 |
| 6.0 | 0.0 | .0307 | .0209 | .0053 | 1.47 | 16.0 | 0.0 | .1219 | .0558 | .0058 | 2.18 |
| 8.0 | 0.0 | .0471 | .0256 | .0058 | 1.84 | 18.0 | 0.0 | .1446 | .0680 | .0058 | 2.13 |
| 10.0 | 0.0 | .0665 | .0312 | .0058 | 2.13 | 20.0 | 0.0 | .1676 | .0829 | .0058 | 2.02 |

(c) Body-wing

| $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ | $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | 0.0045 | 0.0293 | 0.0052 | 0.15 | 8.0 | 0.0 | 0.1667 | 0.0567 | 0.0055 | 2.94 |
| 2.0 | 0.0 | .0357 | .0314 | .0052 | 1.14 | 10.0 | 0.0 | .2180 | .0738 | .0058 | 2.95 |
| 4.0 | 0.0 | .0788 | .0364 | .0052 | 2.16 | 12.0 | 0.0 | .2721 | .0946 | .0057 | 2.88 |
| 6.0 | 0.0 | .1222 | .0449 | .0052 | 2.72 | | | | | | |

(d) Body-tail

| $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ | $\alpha$ | $\beta$ | $C_L$ | $C_{D_T}$ | $C_{D_B}$ | $L/D_T$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.0 | -0.0027 | 0.0329 | 0.0056 | -0.08 | 6.0 | 0.0 | 0.0646 | 0.0414 | 0.0056 | 1.56 |
| 2.0 | 0.0 | .0190 | .0343 | .0056 | .55 | 8.0 | 0.0 | .0892 | .0484 | .0055 | 1.84 |
| 4.0 | 0.0 | .0408 | .0367 | .0056 | 1.11 | | | | | | |
| 4.0 | 0.0 | .0393 | .0364 | .0056 | 1.08 | | | | | | |




L-86688

Figure 1.- Photograph of complete-model configuration.

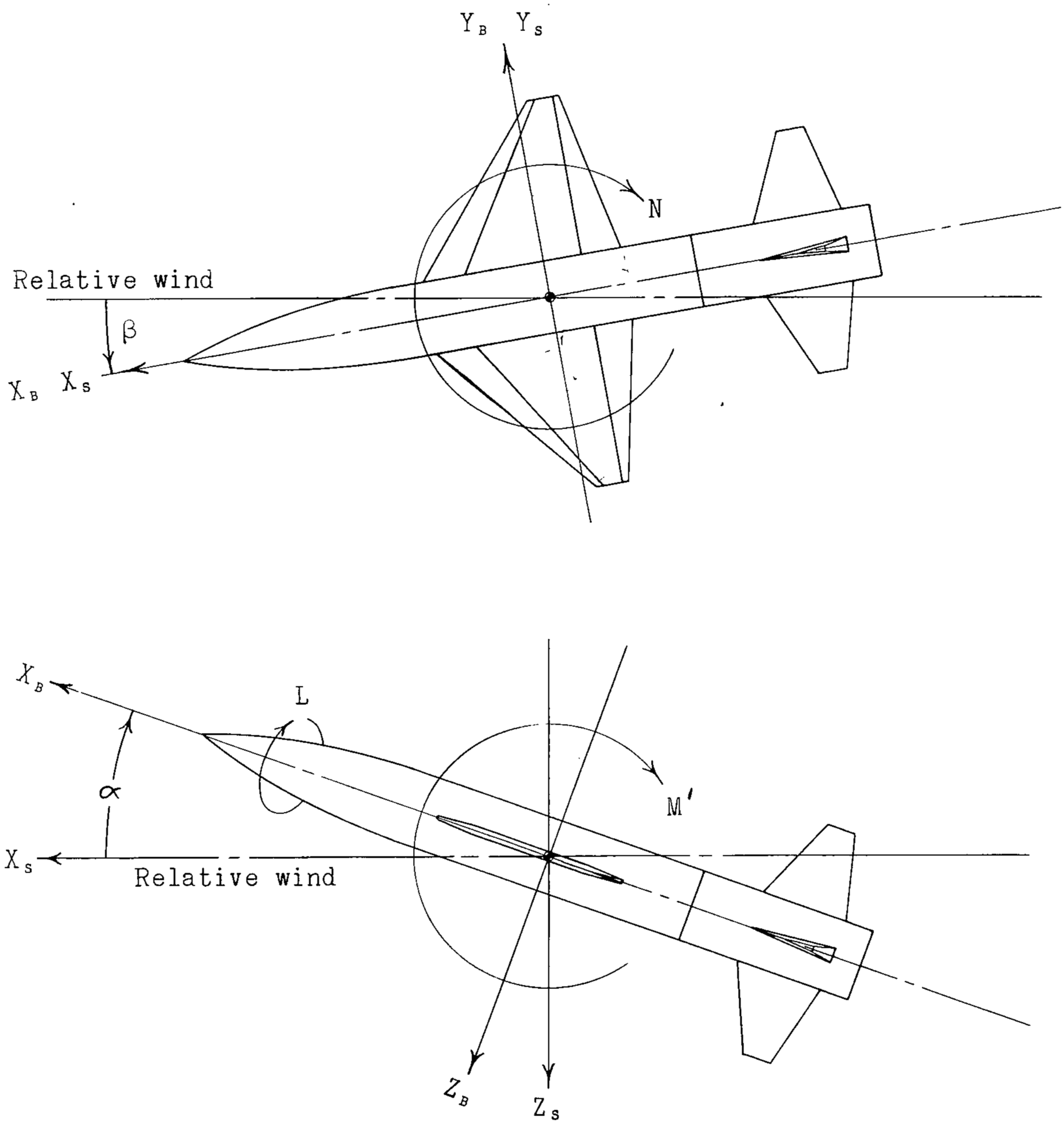



Figure 2.- Systems of reference axes. Subscript B indicates body axes; subscript S indicates stability axes.

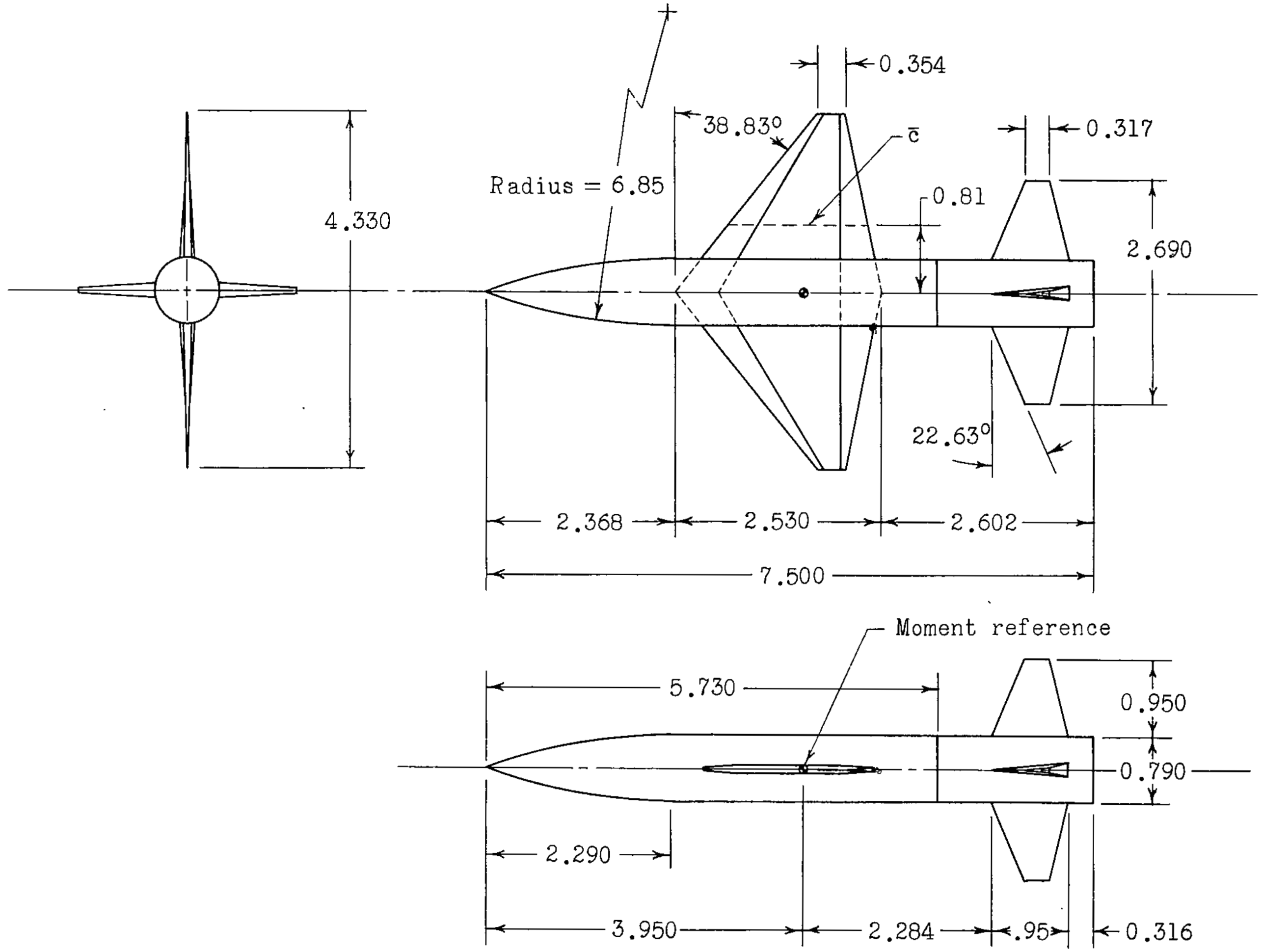
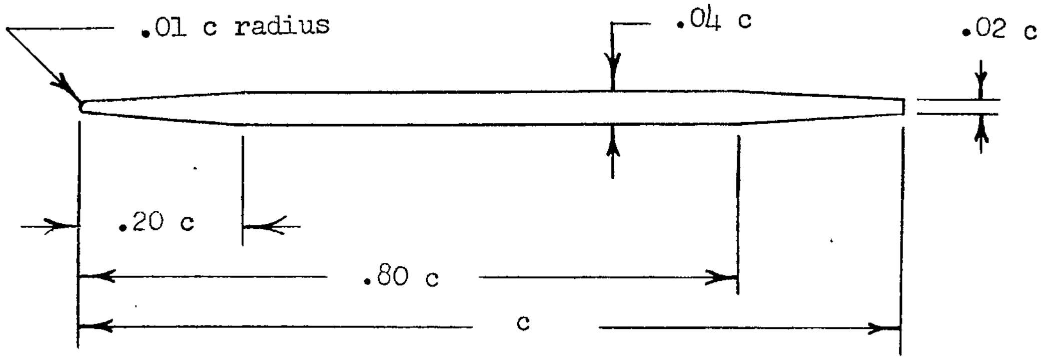
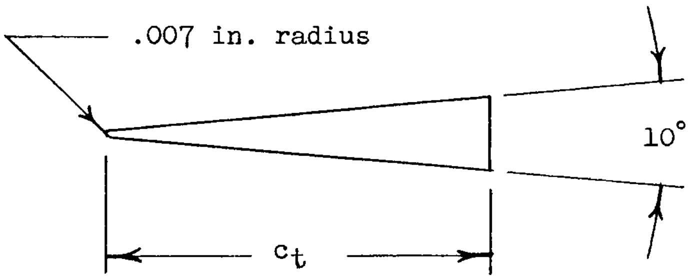



Figure 3(a).- Wind-tunnel model. All dimensions are in inches.

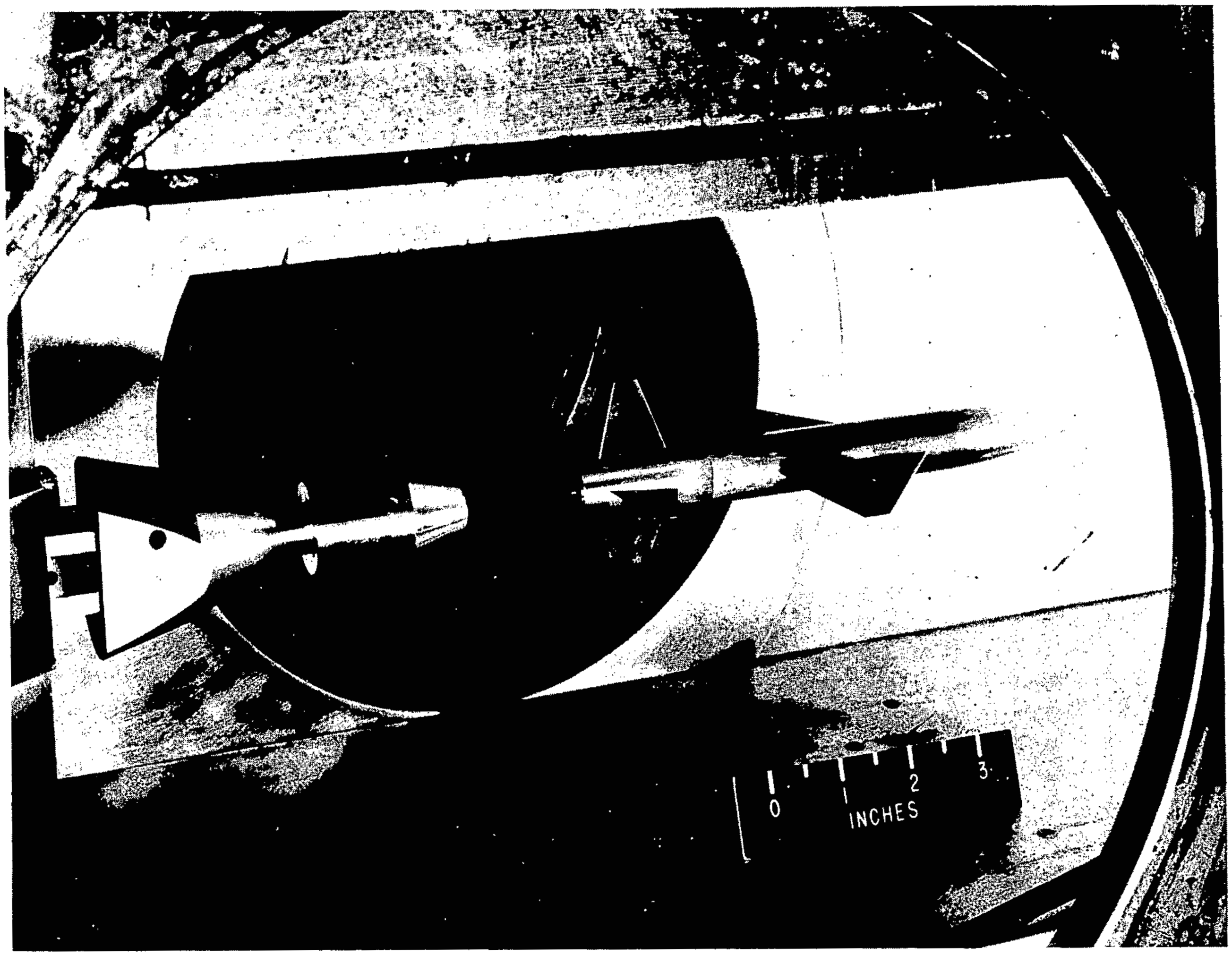



(a) Wing.



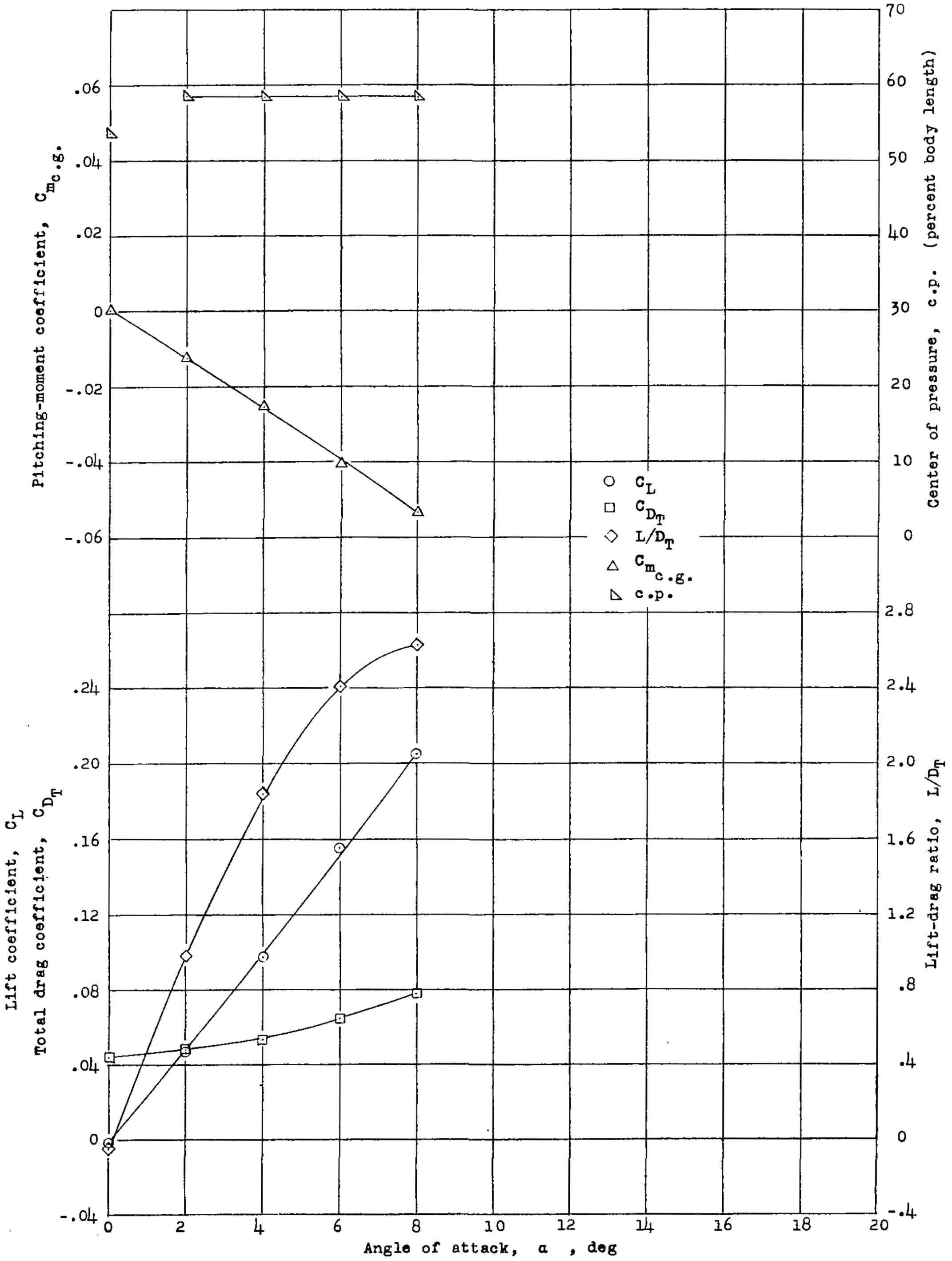

(b) Horizontal and vertical tails.

Figure 3(b).- Wing and tail airfoil sections used on model.



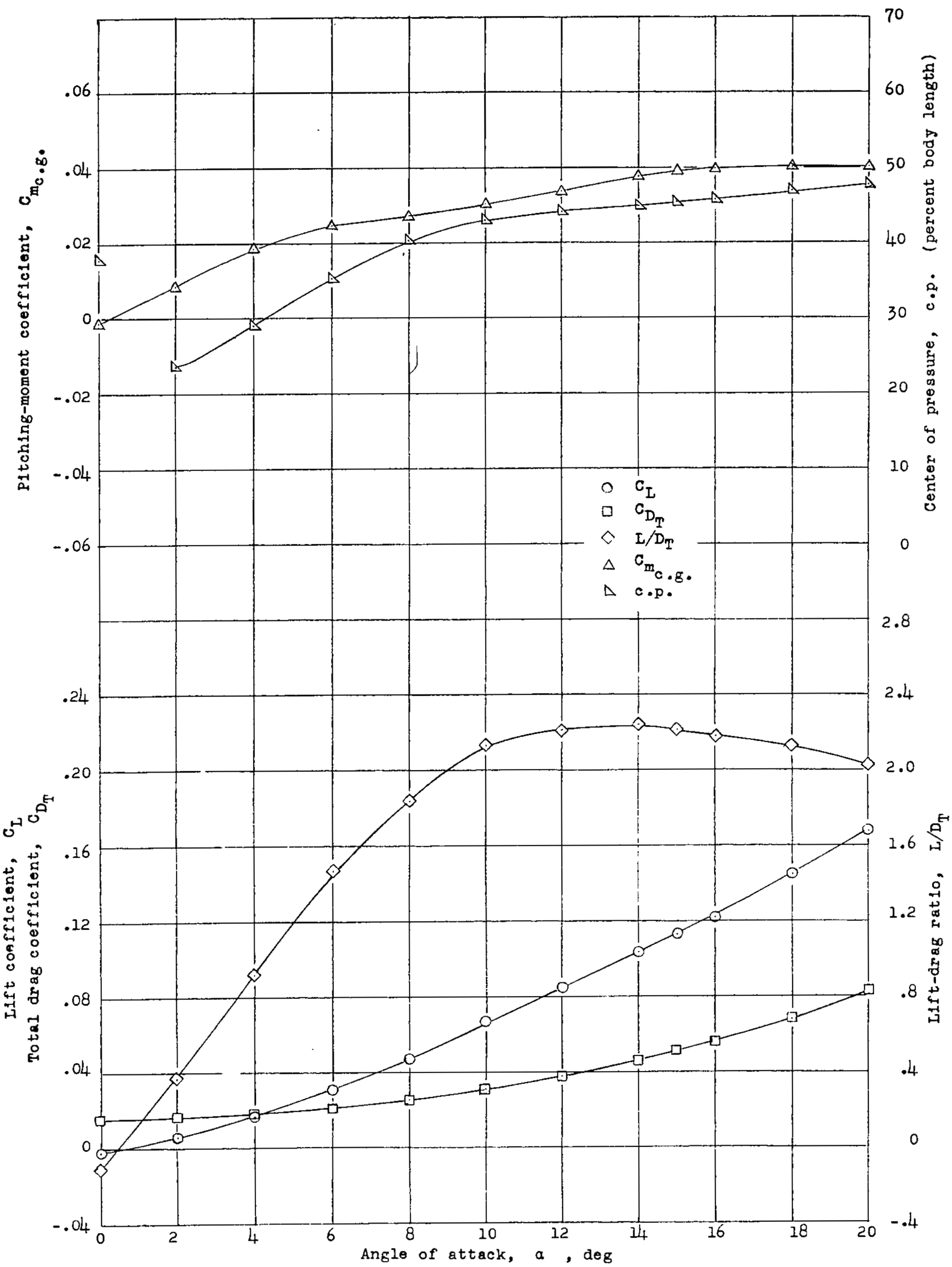

L-87425

Figure 4.- Installation of the wind-tunnel model in the Langley 9- by 9-inch Mach number 4 blowdown jet.



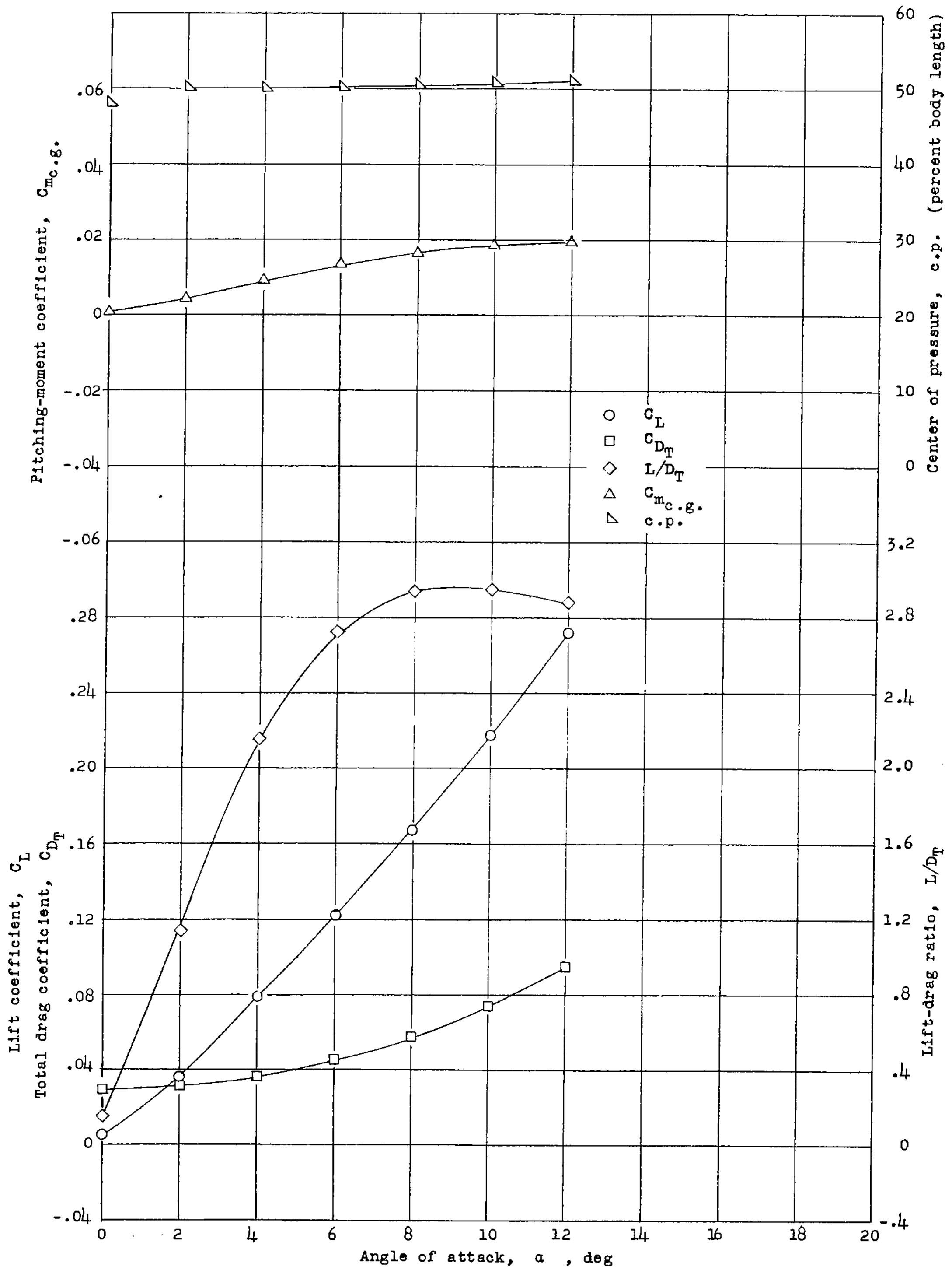

(a) Body-wing-tail.

Figure 5.- Variation with angle of attack of the static longitudinal characteristics of an airplane configuration and its components. $M = 4.06$; $R = 2.7 \times 10^6$.



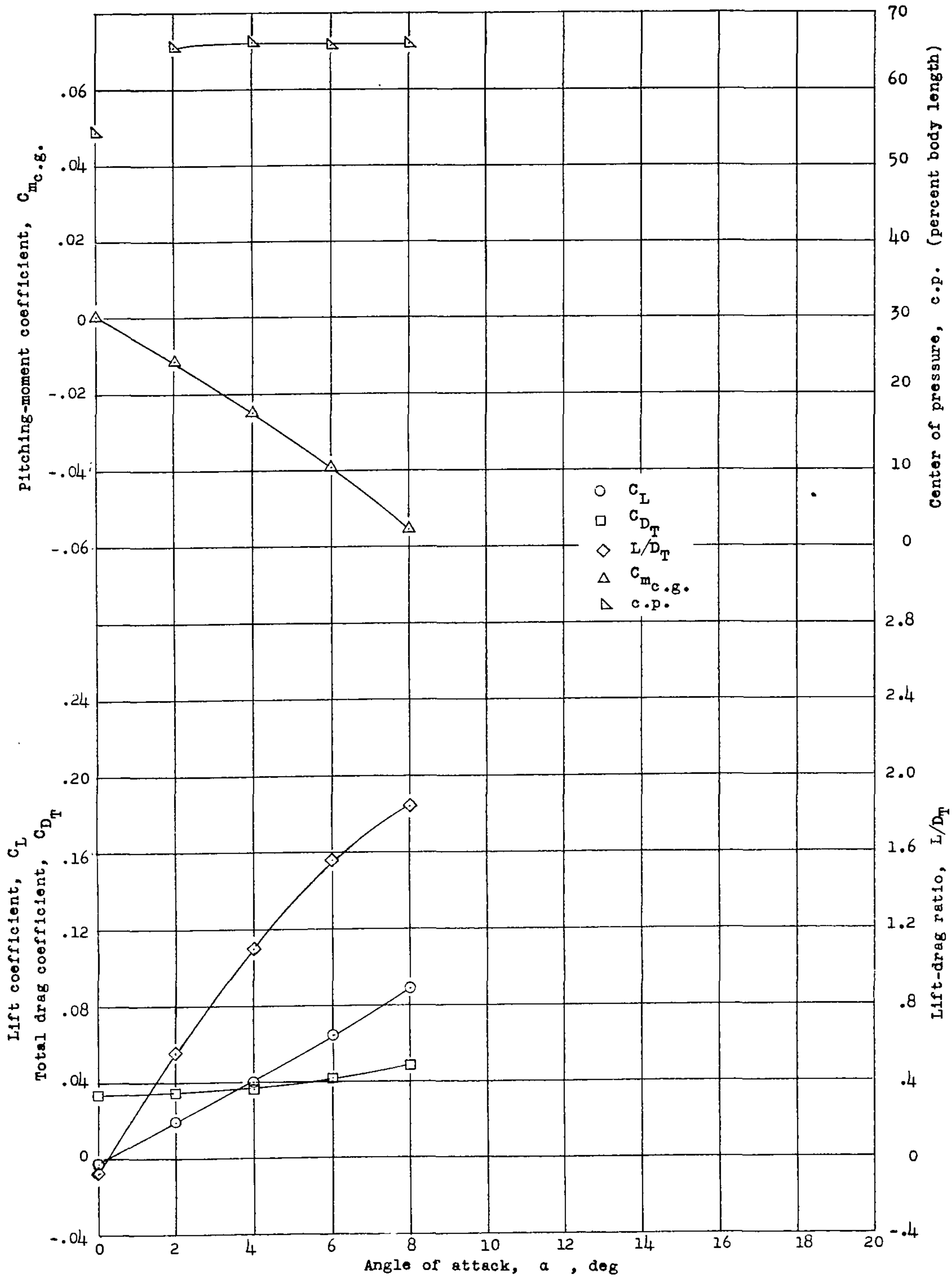

(b) Body.

Figure 5.- Continued.




(c) Body-wing.

Figure 5.- Continued.




(d) Body-tail.

Figure 5.- Concluded.

[redacted]

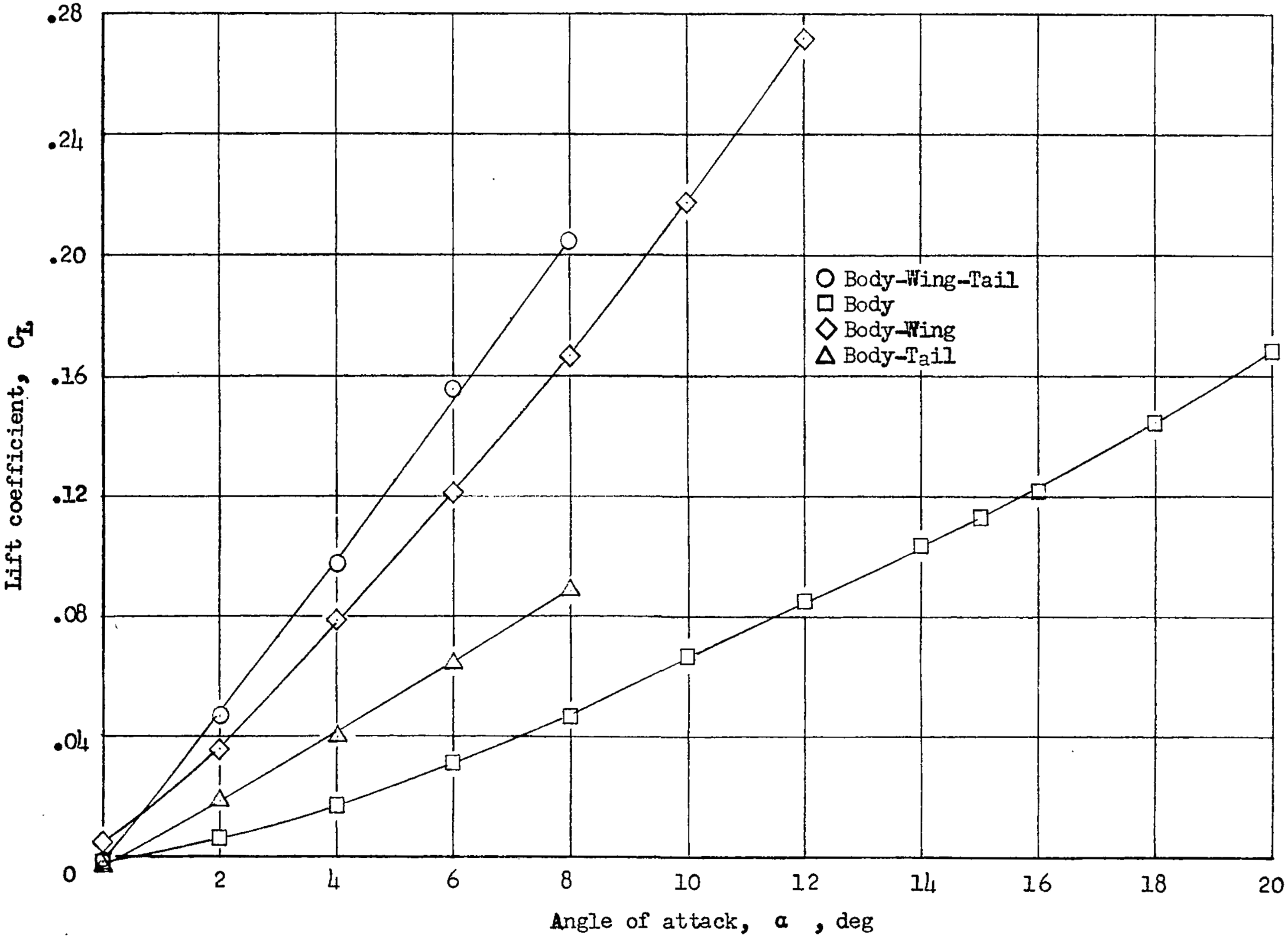



Figure 6.- Variation of lift coefficient with angle of attack for an airplane configuration and its components. $M = 4.06$; $R = 2.7 \times 10^6$.

[redacted]

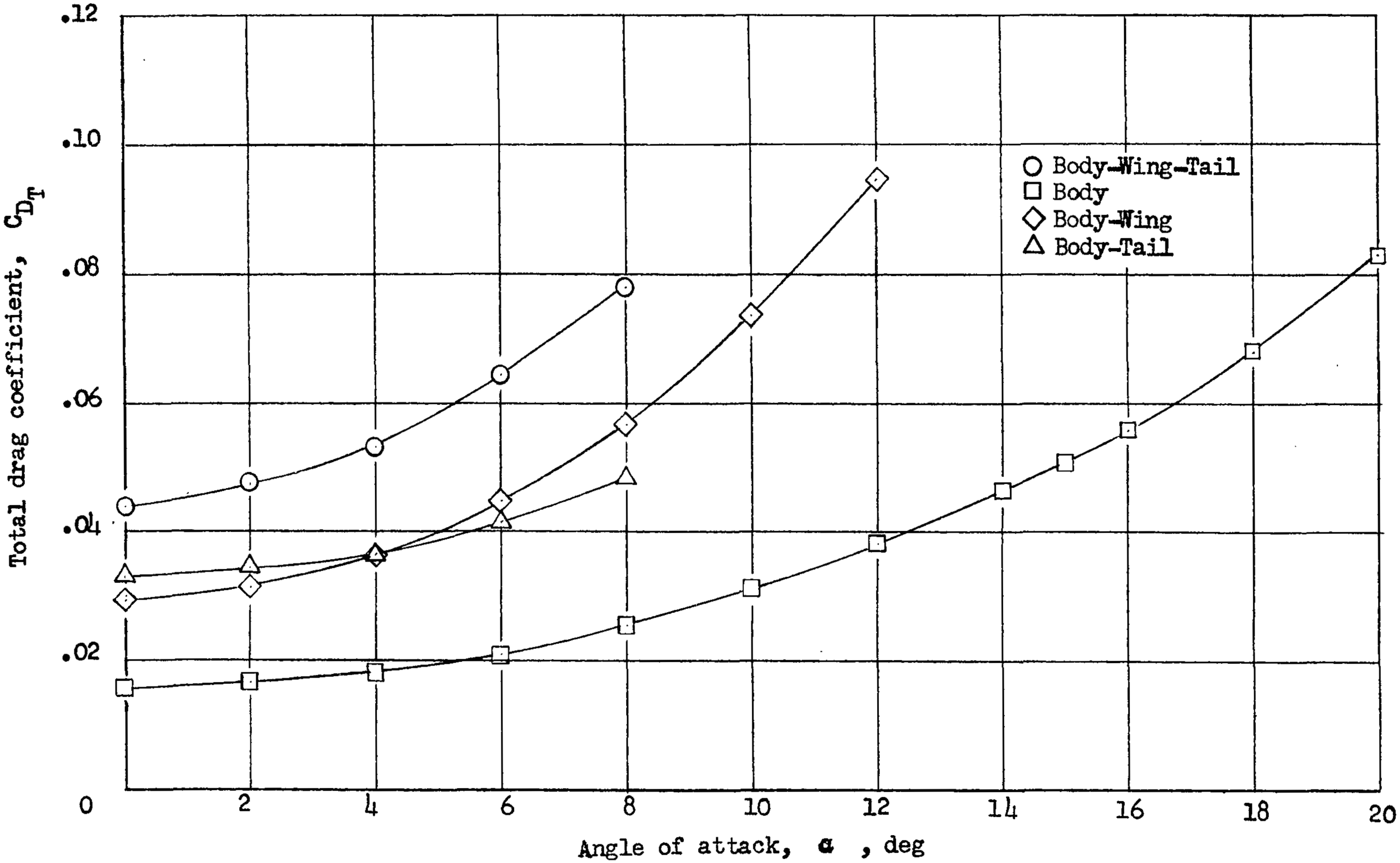



Figure 7.- Variation of total drag coefficient with angle of attack for an airplane configuration and its components. $M = 4.06$; $R = 2.7 \times 10^6$.

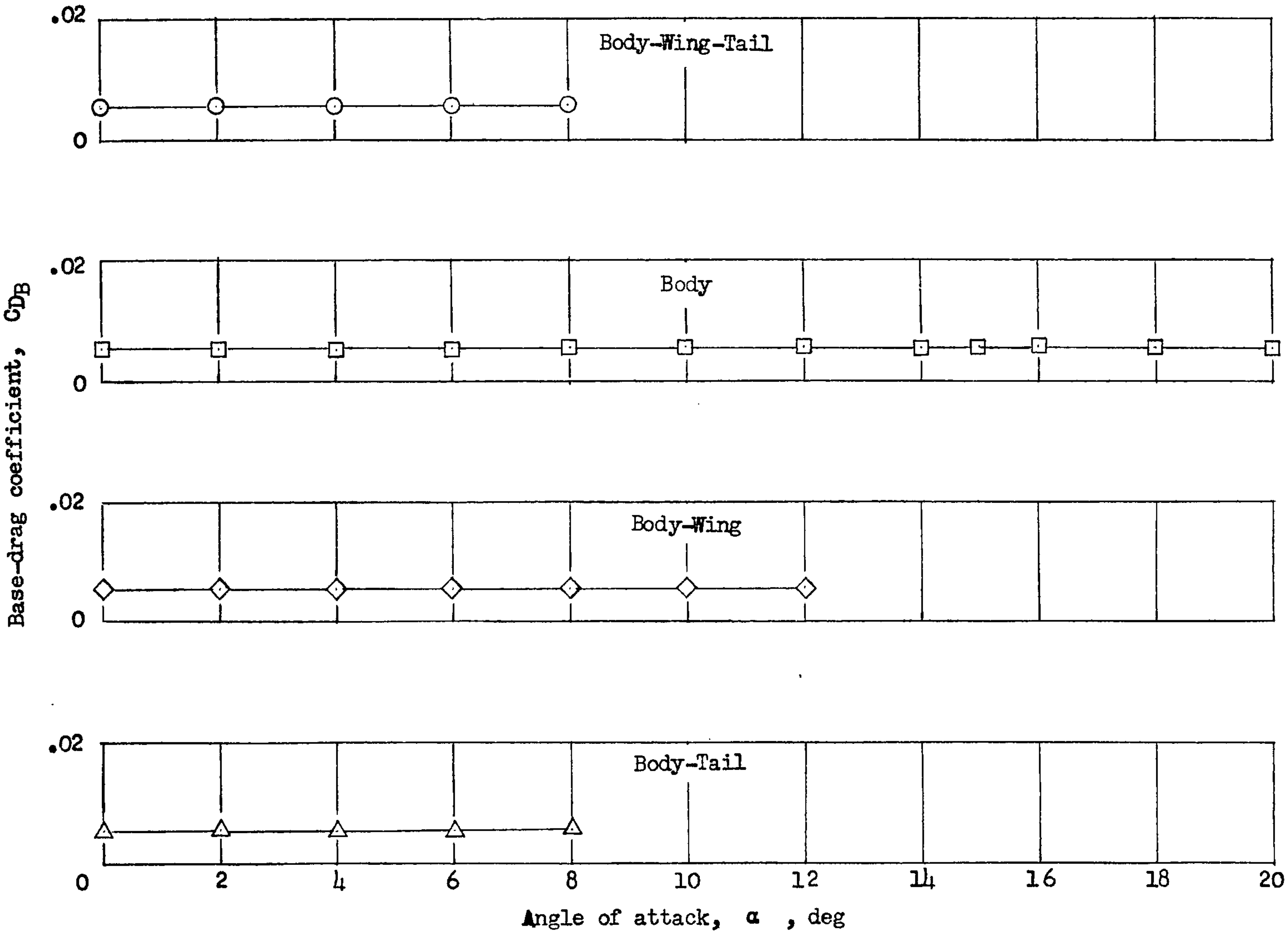



Figure 8.- Variation of base drag coefficient with angle of attack for an airplane configuration and its components. $M = 4.06$; $R = 2.7 \times 10^6$.

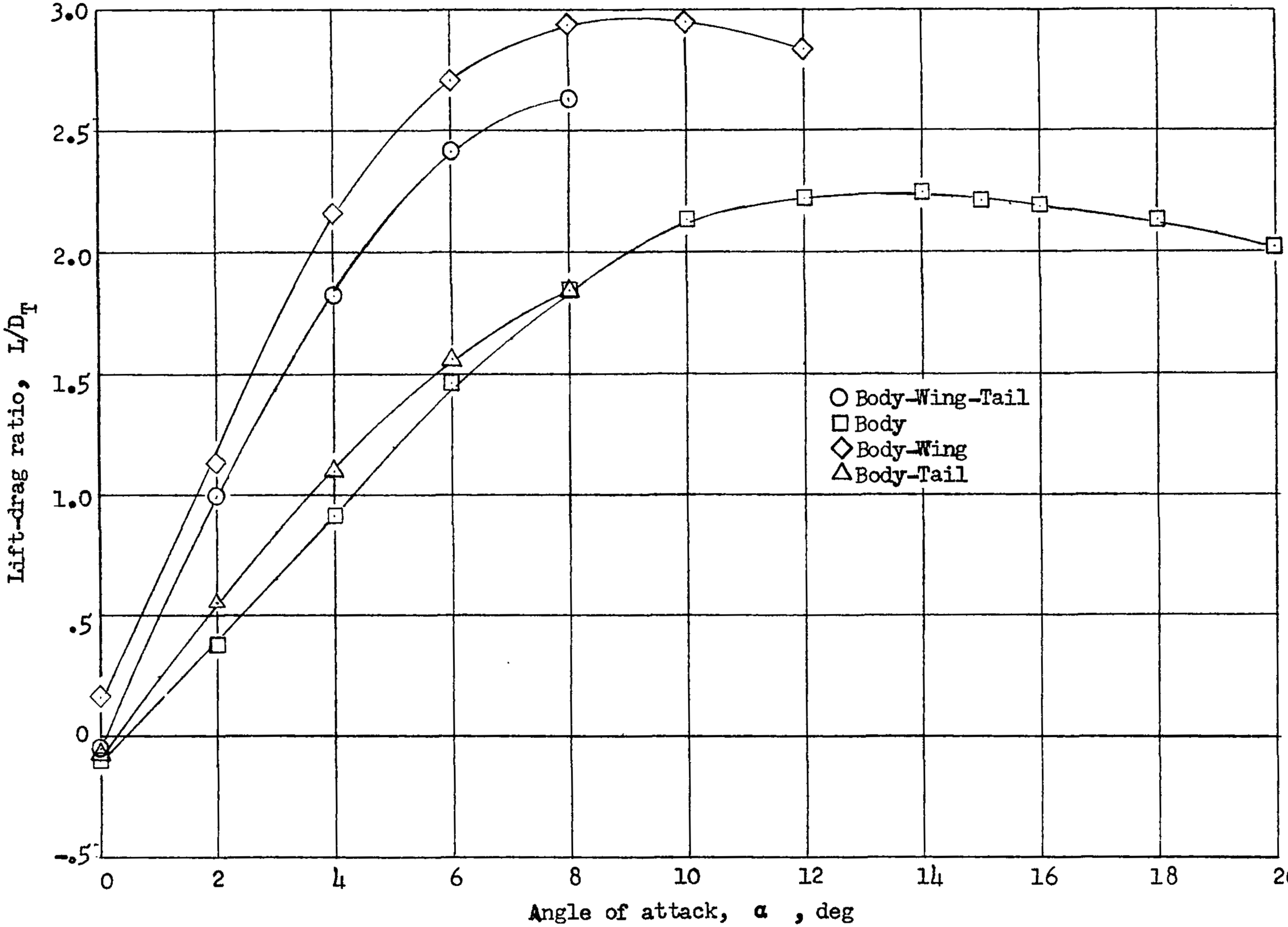



Figure 9.- Variation of lift-drag ratio with angle of attack for an airplane configuration and its components. $M = 4.06$; $R = 2.7 \times 10^6$.

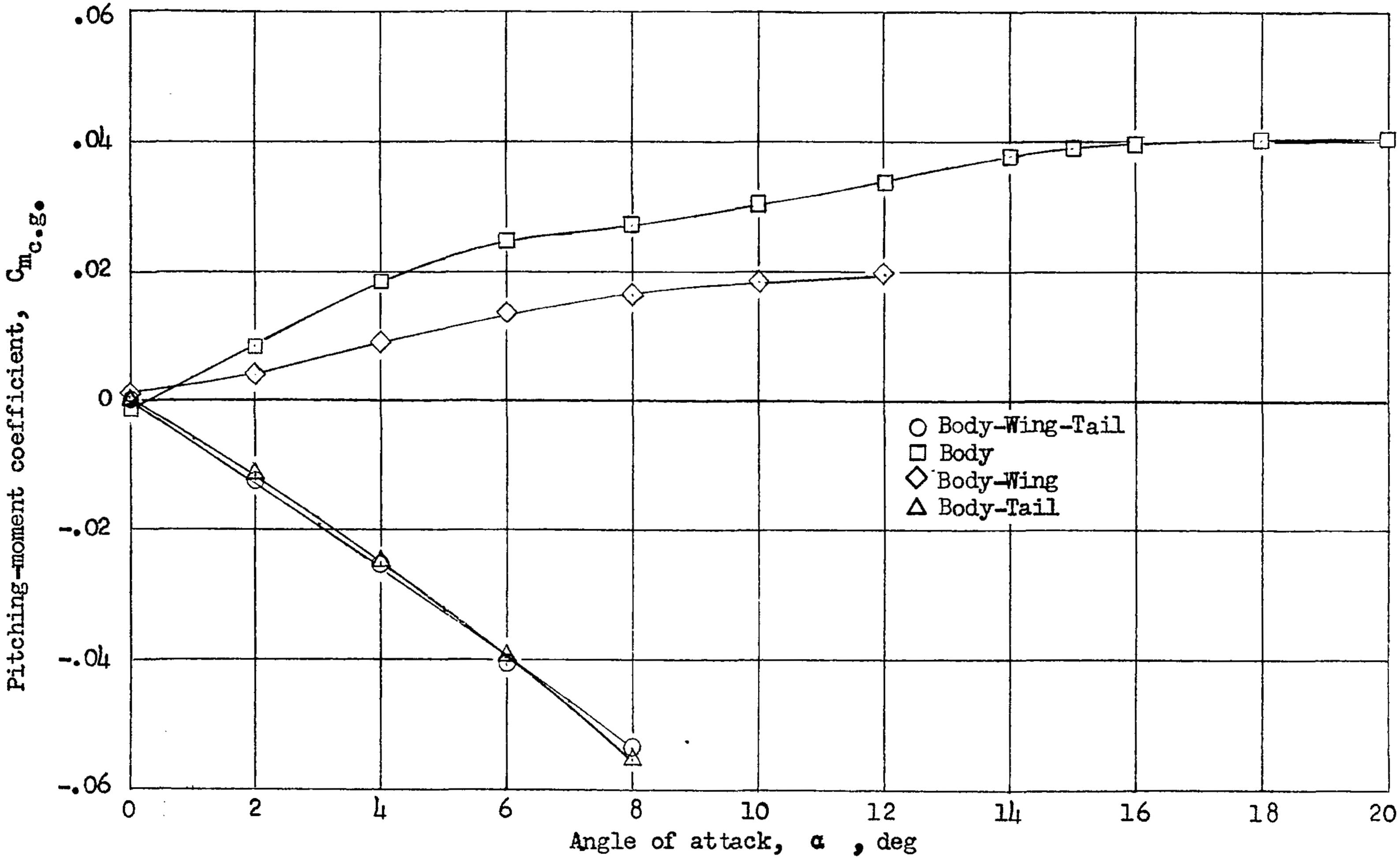



Figure 10.- Variation of pitching-moment coefficient with angle of attack for an airplane configuration and its components. M = 4.06; R = $2.7 \times 10^6$.

[redacted]

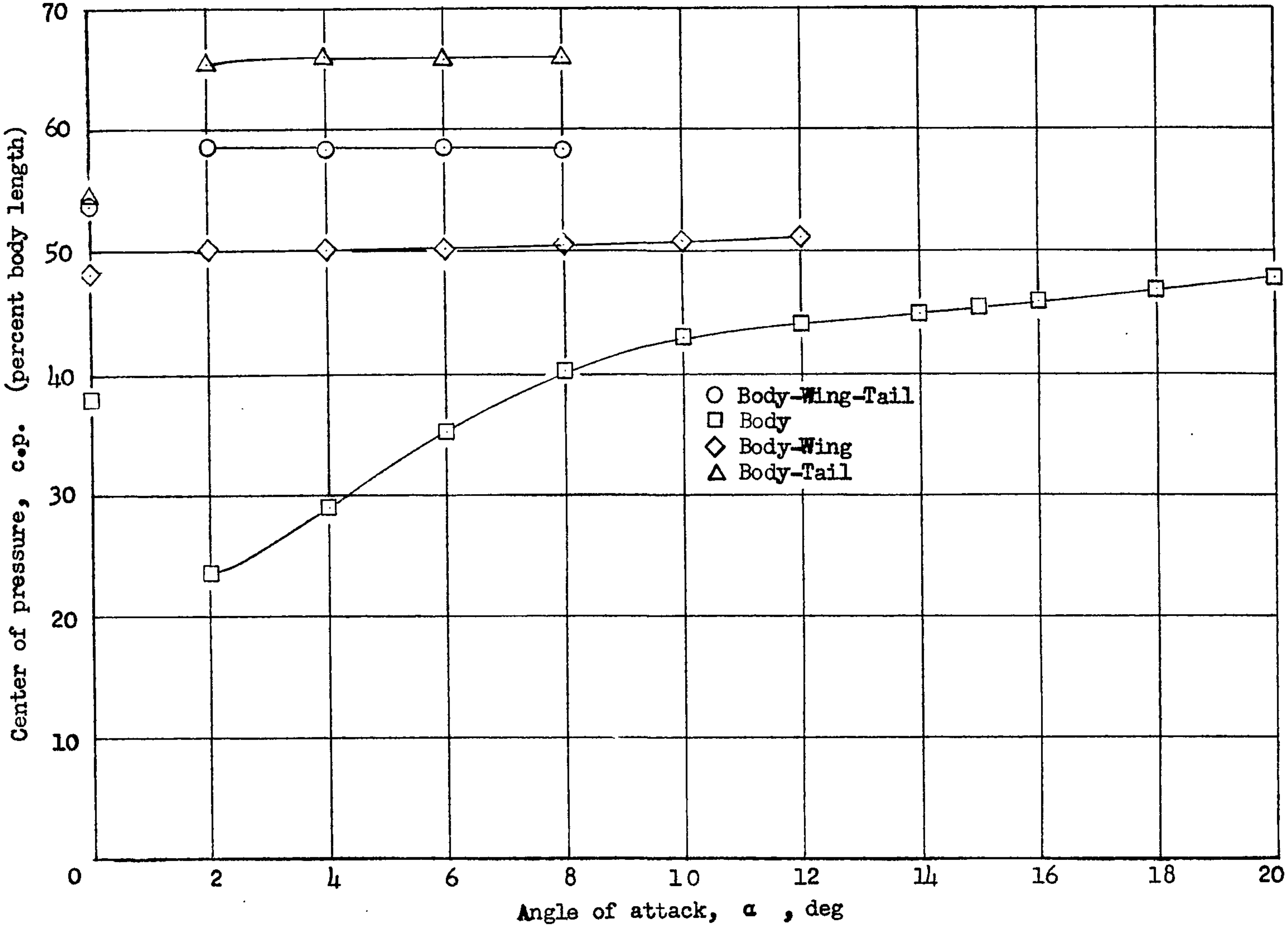



Figure 11.- Variation of longitudinal center of pressure with angle of attack for an airplane configuration and its components. M = 4.06.

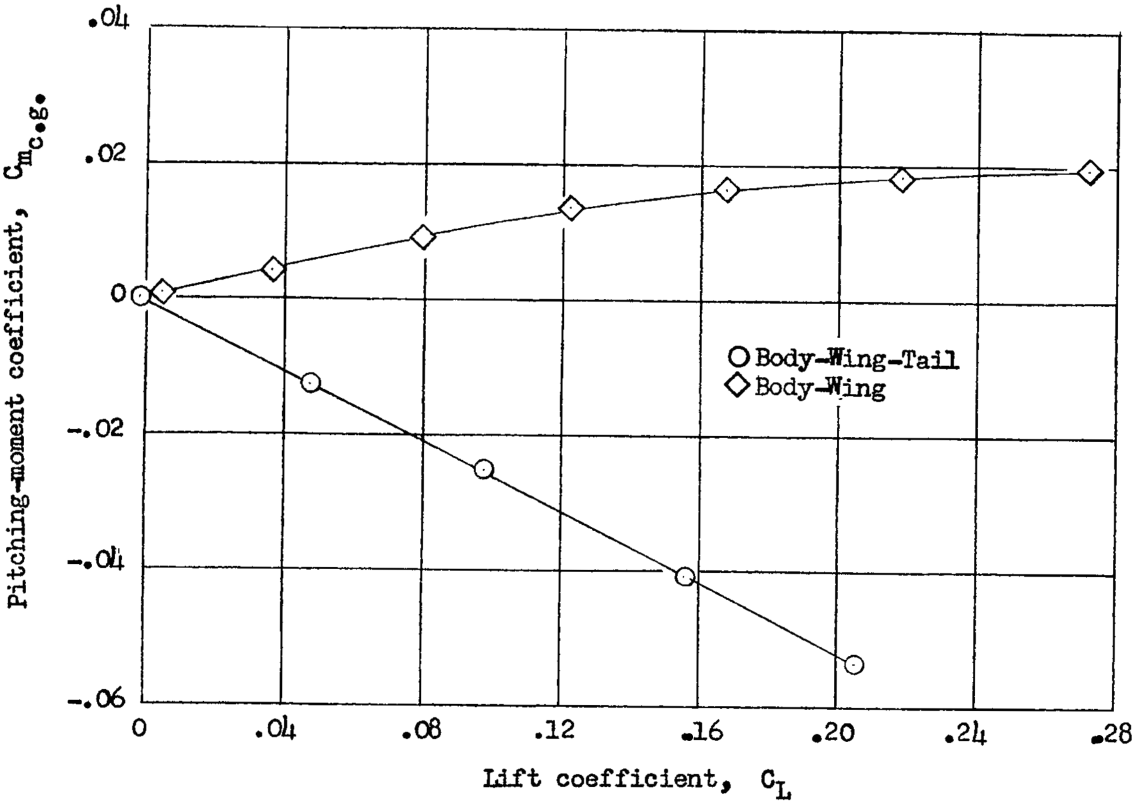



Figure 12.- Variation of pitching-moment coefficient with lift coefficient for an airplane configuration with and without tail fins. $M = 4.06$.

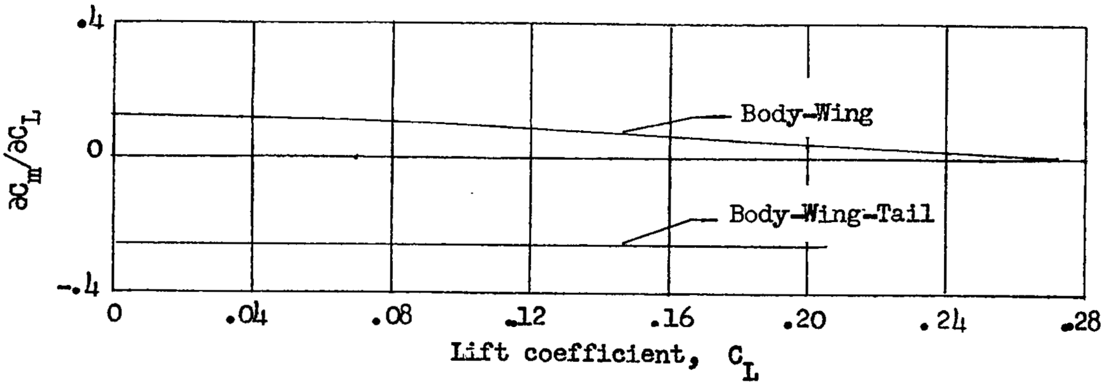



Figure 13.- Variation of the static-longitudinal-stability parameter $\frac{\partial C_m}{\partial C_L}$ with lift coefficient for the complete model and for the body-wing configuration. $M = 4.06$.

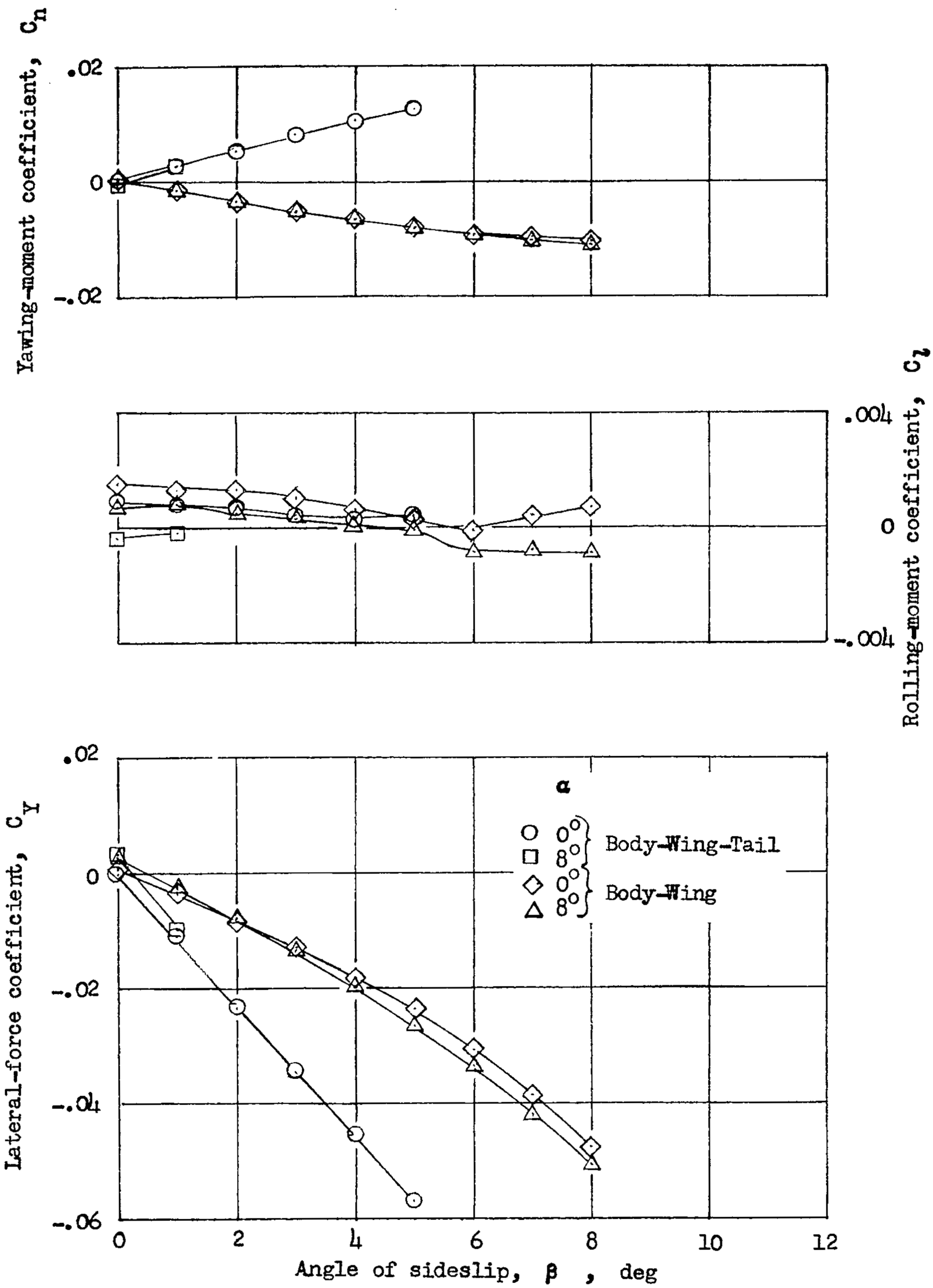



Figure 14.- Variation with angle of sideslip of the static lateral characteristics for an airplane configuration with and without tail fins. $M = 4.06$; $R = 2.7 \times 10^6$.

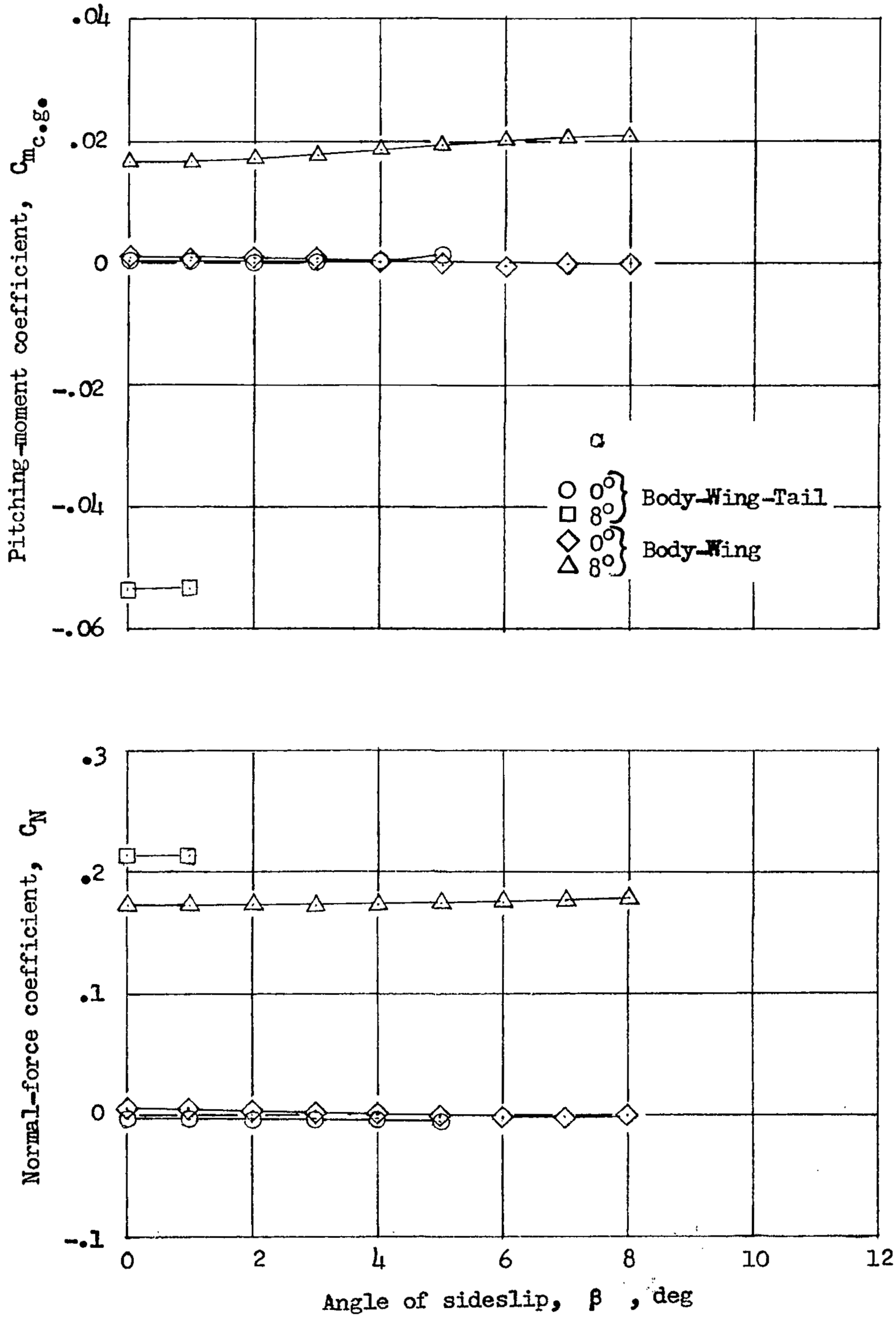



Figure 15.- Variation with angle of sideslip of the static longitudinal characteristics for an airplane configuration with and without tail fins. $M = 4.06$; $R = 2.7 \times 10^6$.

[redacted]

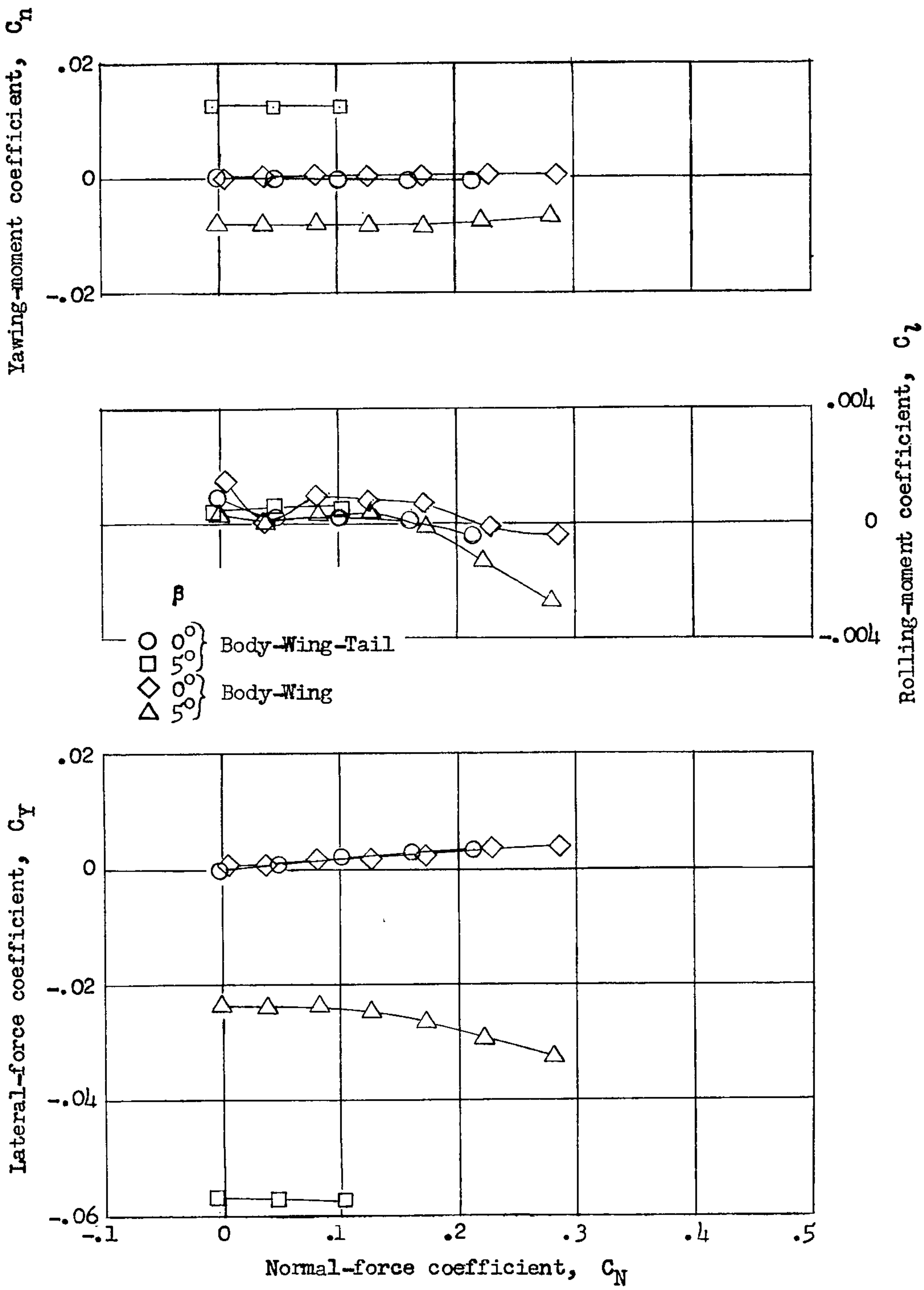



Figure 16.- Variation with normal-force coefficient of the static lateral characteristics for an airplane configuration with and without tail fins. $M = 4.06$; $R = 2.7 \times 10^6$.

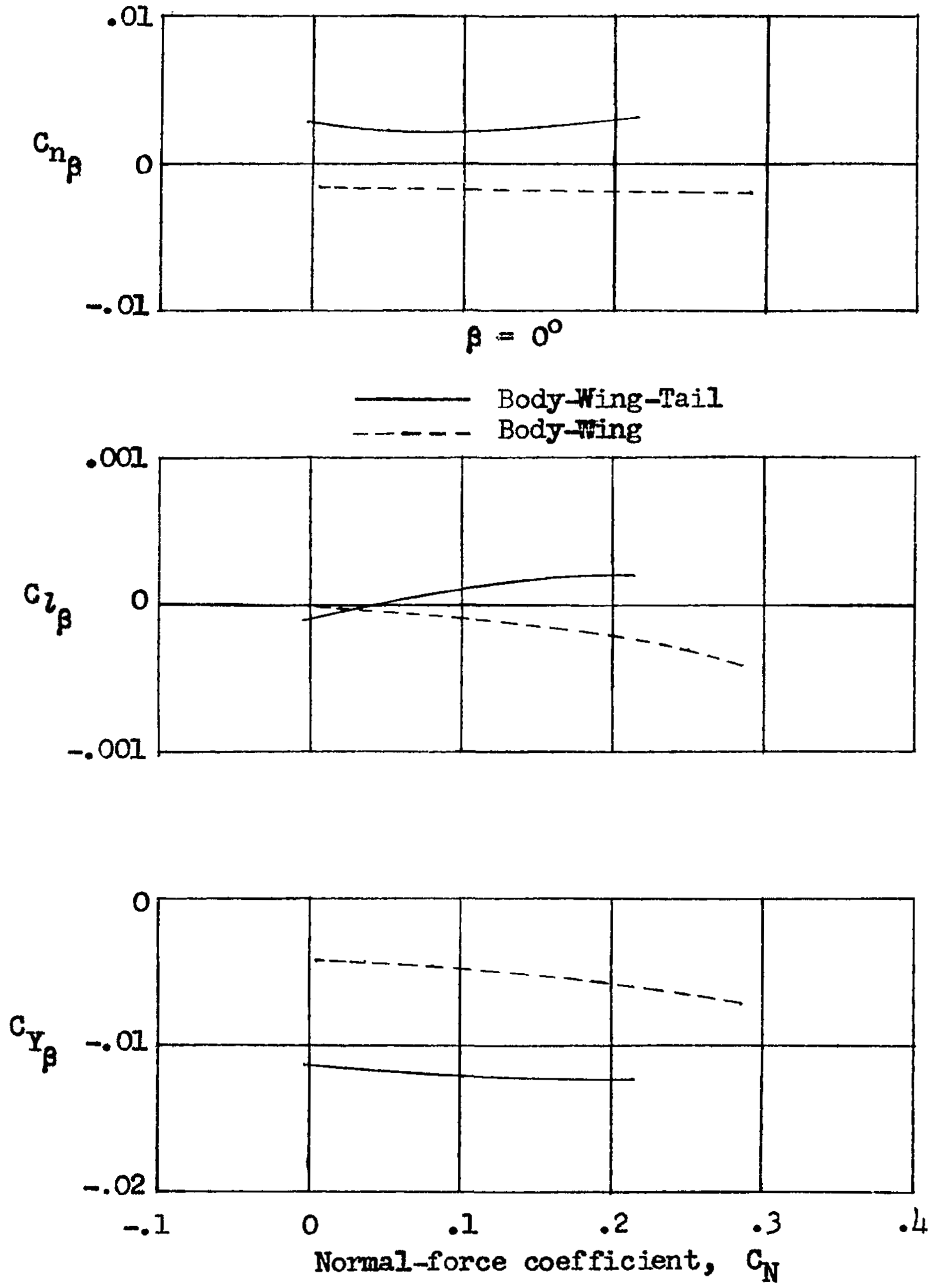
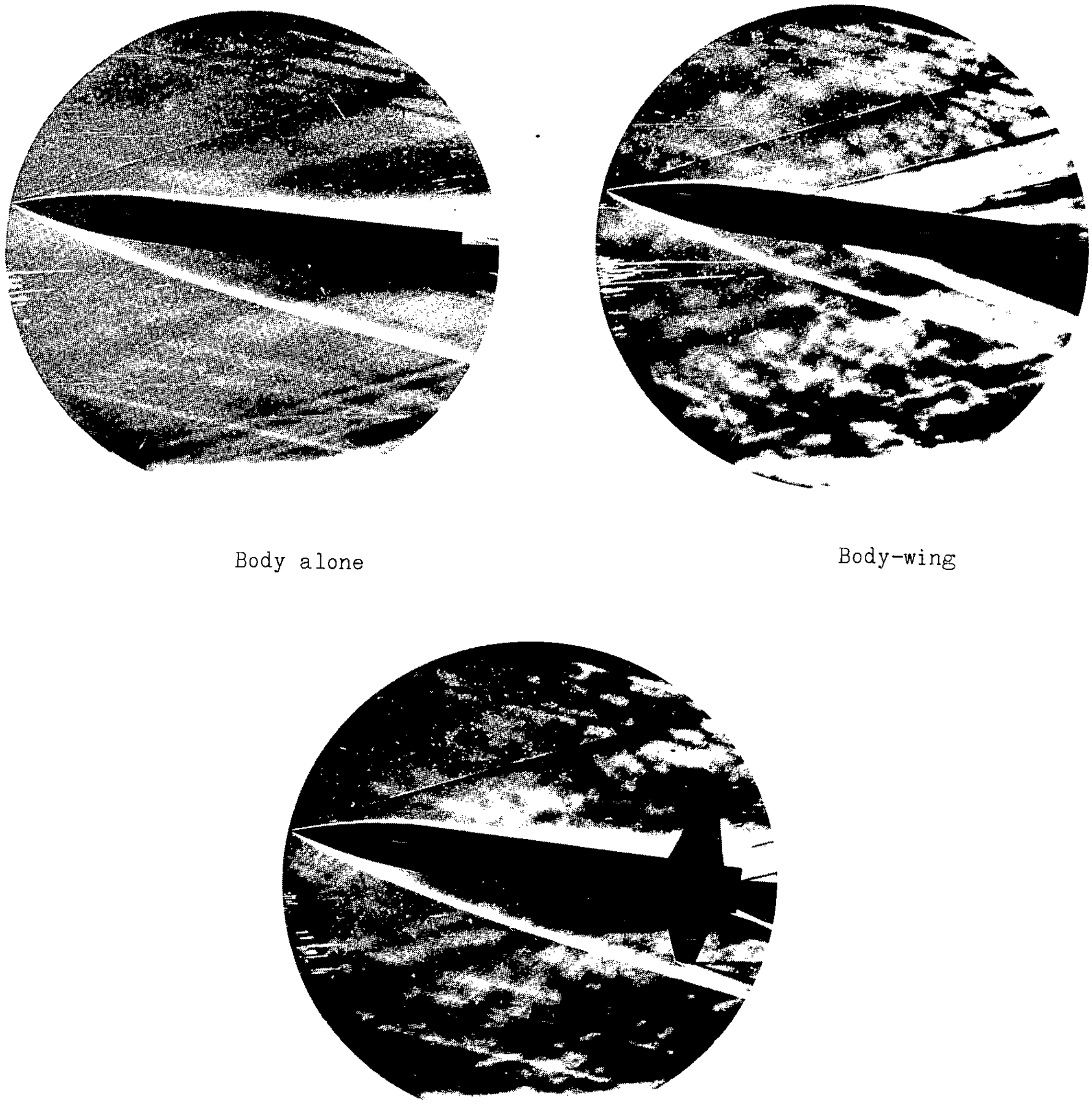
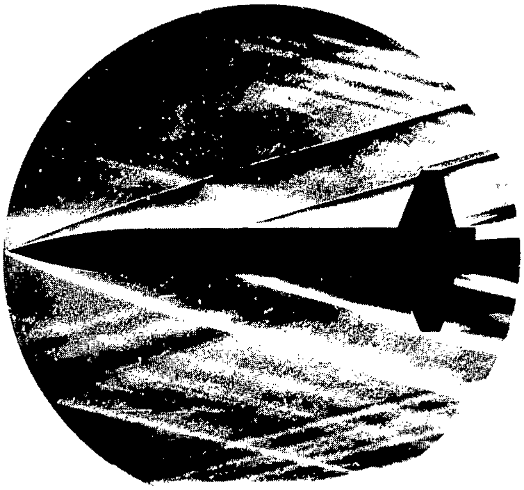



Figure 17.- Variation with normal-force coefficient of the rate of change of the static lateral force coefficients with $\beta$ for an airplane configuration with and without tail fins. $M = 4.06$; $R = 2.7 \times 10^6$.

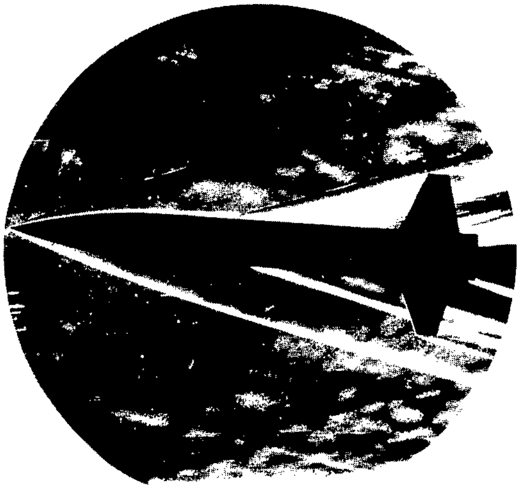



L-87529

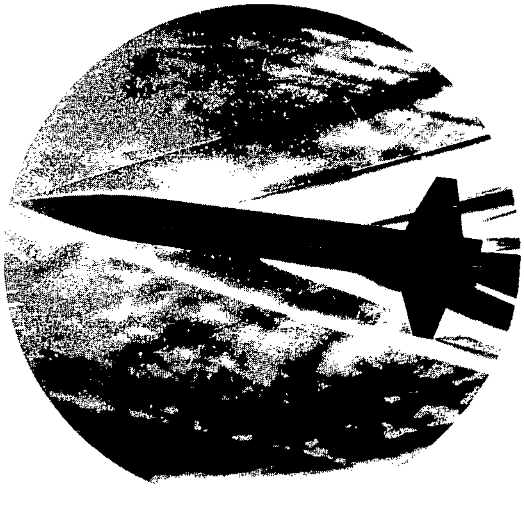
Figure 18.- Schlieren photographs of the flow around the body-alone, body-wing, and body-tail configurations. $\alpha = 8^{\circ}$; $\beta = 0^{\circ}$; $M = 4.06$.



$\alpha = 0^{\circ}$



$\alpha = 4^{\circ}$



$\alpha = 8^{\circ}$

L-87530

Figure 19.- Schlieren photographs of the flow around the complete-airplane configuration. $\beta = 0^{\circ}$; $M = 4.06$.

[redacted]

NACA-Langley - 2-15-55 - 350